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Installation and User Manual

for Solar Power Control System / Hybrid

May, 2015

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1 Introduction

Solar Power Control System / Hybrid (SPCS / H) cabinets are designed to supply three phase induction motors in solar pumping systems. These cabinets have a hybrid power input. They could be supplied simultaneously from a 3-phase AC power grid and from a PV array (*Figure 1.1*).

Example diagram of solar pumps installation:

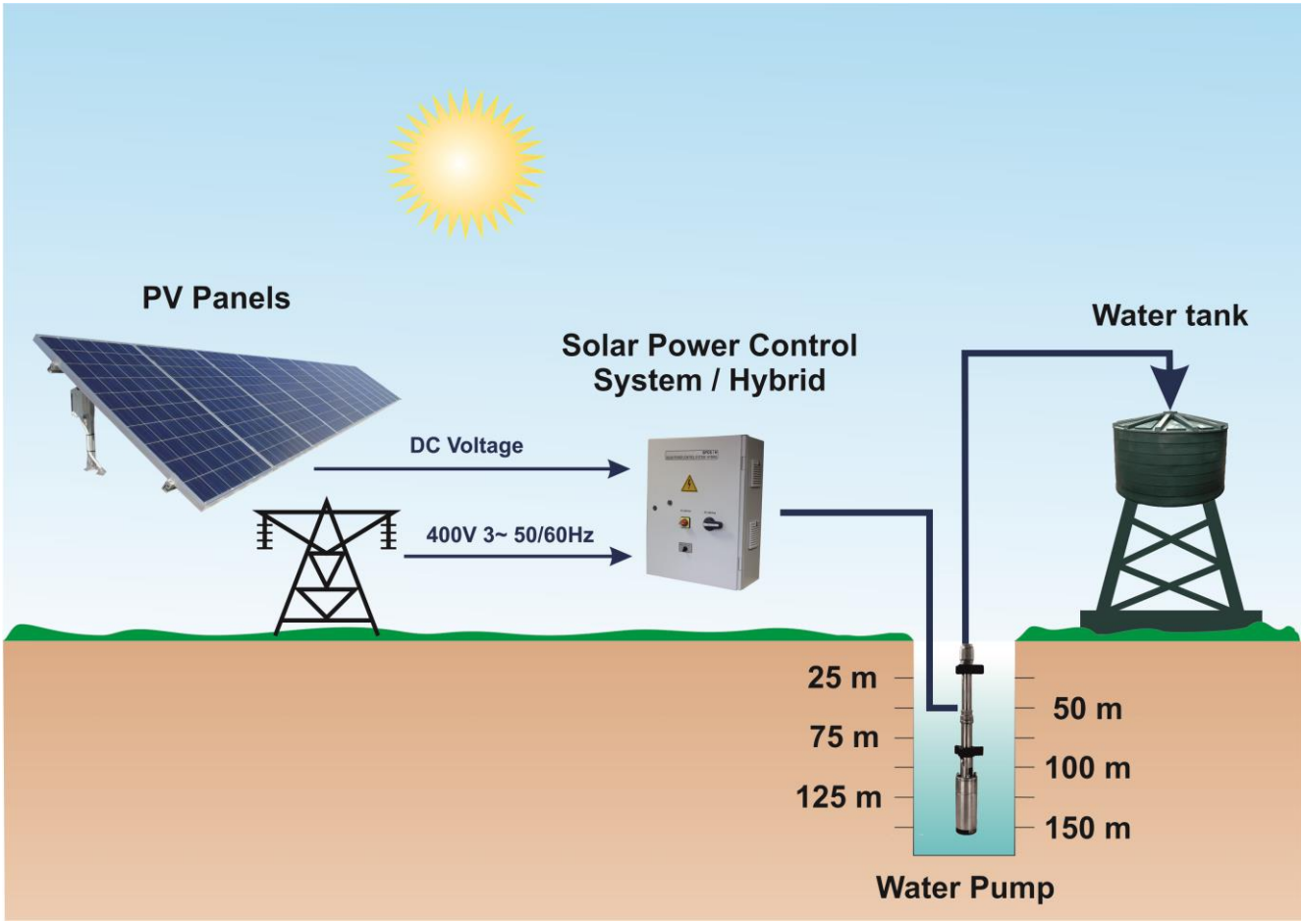


Figure 1.1. Typical Solar Pump Installation

The SPCS / H cabinet works in a proportional mode, when it is supplied from both, an AC grid and PV panels, the device consumes the maximum possible energy from the PV array and, if the solar energy is not enough to feed the pump (with its rated power), then it consumes the rest necessary energy from the AC power grid.

The SPCS / H cabinet could be supplied also only from one power source. For example, only from a PV array. The AC power grid could be switched on from the AC power switch (on the front panel of the cabinet), only when the customer needs it.

The SPCS / H cabinet includes Inverter module, HPSI module, AC grid and PV side arresters, PV fuse holders, AC and DC Switches, Control Switch. Optional there could be included communication modules and water level control module.

1.1 Instructions for safety operation

The present manual contains important instructions for safety operation, start running into exploitation and operation cabinets type SPCS / H!

This manual has to be kept together or near the equipment any time!

Photovoltaic installations operate with dangerous for life voltages. All activities regarding assembling and maintenance have to be performed by authorized personnel, familiar with installation, start running into exploitation and operation of photovoltaic equipment and installations. The unit must be used exclusively for purposes, for which it is intended. For good and safety operation of the product, it is important the transport and store keeping to be good, as well as all prescriptions for assembling and installation, service and maintenance to be kept. Respective regional and specific for the country regulations to be kept, as well as the requirements, described in the present document, including instructions for location and assembling (for example the cross section of connecting cables, performing the tightening torque on mechanical and electrical connections, etc.).

Used symbols and warning signs:

DANGER

DANGER means risky situation which, if it is not avoided, can bring to death or to serious injury.

ATTENTION

ATTENTION refers to cases, which are not connected with human injury. Not conforming to this warning sign can bring to material damages.

1.2 Warranty

The data and instructions for assembling and maintenance, given in this manual, are revised regularly and all corrections are included in next issues. In case of breaking the assembling instructions, the warranty claims will not be accepted. We cannot bear any responsibility also in cases of incidents and material damages, caused from wrong use, as well as from actions of not authorized personnel with resulting from these consequences.

1.3 Scope of delivery

Table 1.1 Scope of delivery

Q- ty	Item
1 pc	SOLAR POWER CONTROL SYSTEM / HYBRID – SPCS / H unit
1 pc	Plastic universal key
1 set	Wall mounting kit (Set of mounting plates with bolts)
1 pc	Installation and User Manual
4 pcs	Spare fuses (15A) for the strings

1.4 Technical parameters

The basic technical parameters of Solar Power Control System / Hybrid with power 7.5kW, 11.0kW, 15.0kW and 19.0kW are listed in *Table 1.2*.

Table 1.2 Technical parameters

Type		***SPCS / H***			
Main Application		Drive power – matched three-phase pumps			
Output Power (Motor Pump Power)	kW	7.5	11.0	15.0	19.0
Output Voltage (Motor Supply Voltage)	V_{AC}	3x400			
Input PV Voltage Range	V_{DC}	560 – 800			
Max. V_{OC}	V_{DC}	800			
Max. Input DC current per DC input	A_{DC}	15			
Available Number of PV string inputs	Q-ty	3	4	5	6
Recommended PV Panels Power	Wp	235 – 250			
Recommended Total PV Panels Power	Wp	14400	19200	24000	28800
Recommended number of strings	Q-ty	3	4	5	6
Recommended PV panels per string	Q-ty	18 - 20			
Protection Class		IP 54			
AC and DC switches		Build in			
PV inputs individual protection		By fuses			
Input AC Grid Voltage	V_{AC}	380 - 420 3~ 50/60Hz			
Input AC Grid Current	A_{AC}	16	28	35	40
Operation modes		Manual / Fully automatic			
Technology		Advanced MPPT; IGBT Power Modules			
Protections	Electronic	DC Input reversal; Over Load Protection; Output Short circuit; Earth fault protection; Over Voltage; Under Voltage; Over Heating; Dry Run			
	System	Lightning protection by surge arresters			
System Inputs and Outputs - **Option 1**	Digital	4 Digital Inputs; 1 Digital Counting Input			
	Analogue	1 Analogue Input 4- 20mA			
	Relays	2 NO/NC			
	Digital	2 Open Collector Outputs			
Inverter Communication Interface		Modbus RS232 / RS485			
Communication with SPCS / H	**Option 2**	RS232/485 to Ethernet			
	Option 3	RS232 to 3G (GSM communication)			
	Option 4	RS232 to GPRS (GSM communication)			
Water Level Control	**Option 5**	WLC module allows connection of 1 or 2 sets of liquid level sensors			
Weight	kg	42	42	44	44

1.5 Label with technical parameters

The label with the main technical parameters of the unit is located on the upper left inside part of the door.

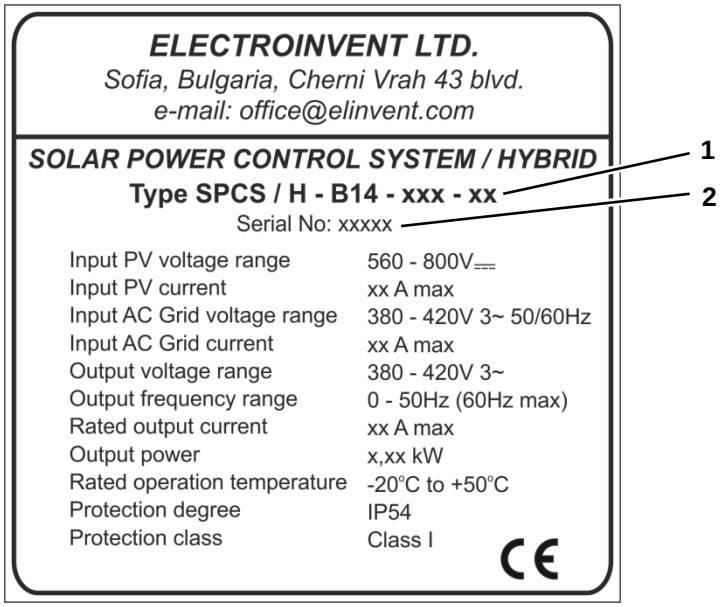
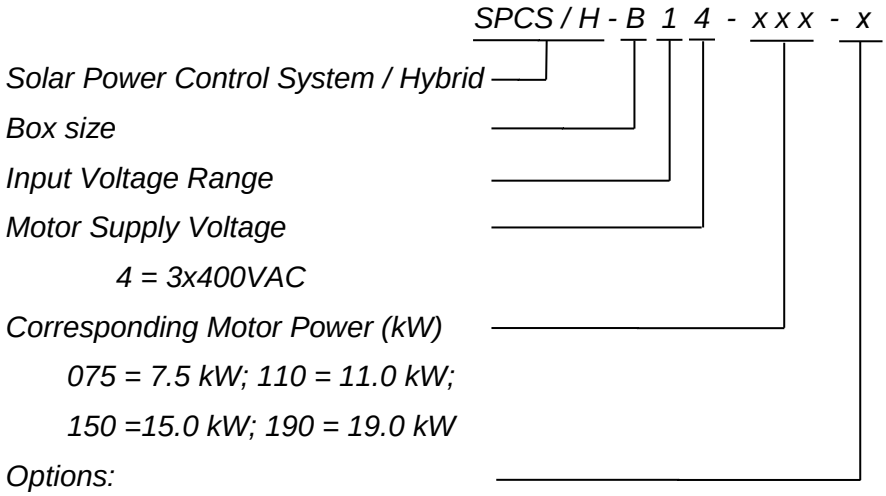


Figure 1.2. Label with technical parameters

Where:
1. Designation of the product
2. Serial number of the product

Description of type designation:



Solar Power Control System / Hybrid

Box size

Input Voltage Range

Motor Supply Voltage

4 = 3x400VAC

Corresponding Motor Power (kW)

075 = 7.5 kW; 110 = 11.0 kW;

150 =15.0 kW; 190 = 19.0 kW

Options:

I - Input / Output Interface

E - Communication module - RS232/485 to Ethernet

G1 - Communication module - RS232 to 3G (GSM communication)

G2 - Communication module - RS232 to GPRS (GSM communication)

W – Water Level Control Module

***Note:** Options G1 and G2 could not be built in the cabinet together.*

Figure 1.3. Description of product designation - see Figure 1.2 pos.1

2 Warnings for danger and attention

DANGER

Regional standards for installation must be observed.

DANGER

Installation, exploitation and maintenance of the unit must be performed by qualified personnel only.

DANGER

The unit operates with dangerous for life voltages. The strings of photovoltaic modules can be under voltage, when DC switch is turned OFF and the fuses of strings are taken out.

DC-link of the unit stays for some time under voltage, even when the AC and DC switches of the unit are turned OFF.

After turning OFF the AC and DC Switches, wait 10 minutes, before opening the cabinet door or turning it ON again!

DANGER

The unit is a part from complete photovoltaic installation. During operation must be observed all instructions for safety, concerning inverter unit and inverter parts, as well as the instructions described in present manual for assembling and exploitation! Have in mind, that after photovoltaic breakdown, automatic restart can follow.

DANGER

If some information is not clear, please, contact with the service center of “ELECTROINVENT” LTD!

ATTENTION

Loss of warranty!

The unit must not be damaged, as well as it is forbidden to make holes on it. Any transport damage has to be established and reported to supplier before unit installation.

3 Installation of Solar Power Control System / HYBIRD

The SPCS / H unit installation must be done in accordance with indicated below steps.

3.1 Mechanical installation

The SPCS / H unit has to be mounted on the wall or on the frame, as the cable terminals must be down. Inside the panel, even during installation, never must enter any water or other liquid.

The fixing of the panel is done by mounting plates, which must be assembled on the back side of the box (see *Figure 3.1.*). The mounting plates and fixing elements are shown on *Figure 3.1*.

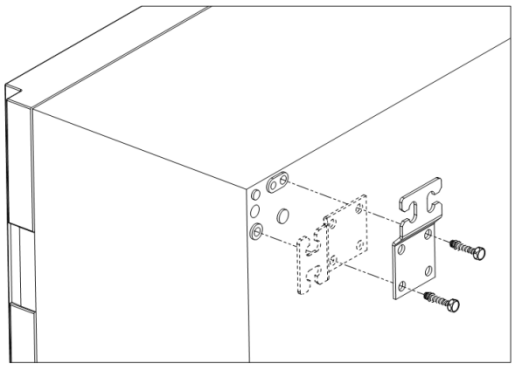


Figure 3.1. Assembling of mounting plates

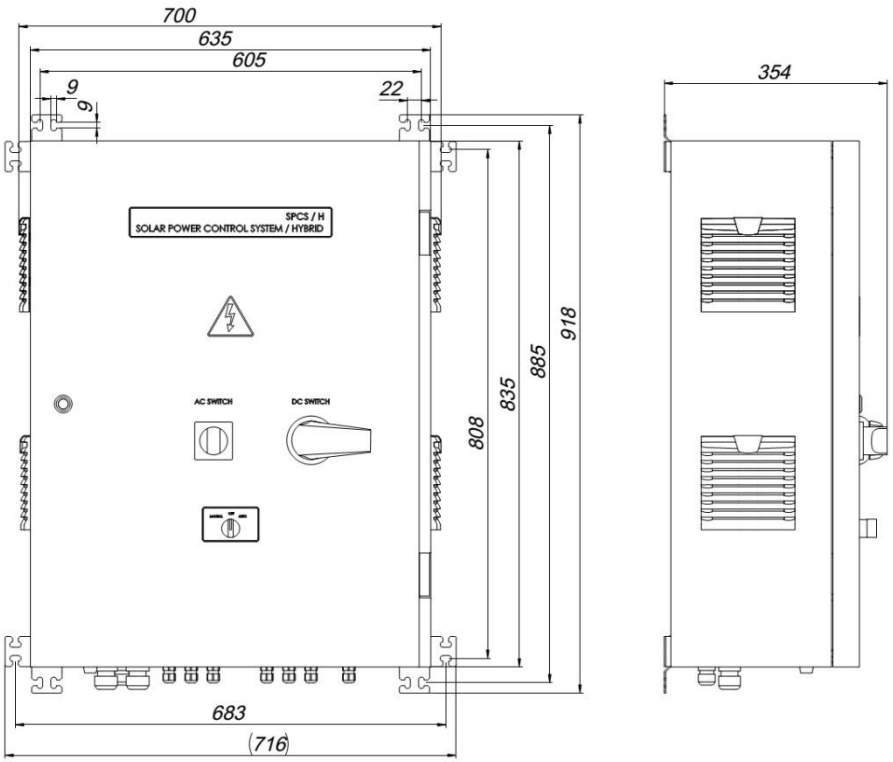


Figure 3.2. Overall and mounting dimensions

Note: Condensate discharge unit (see *Figure 3.3*) must not be covered. The condensate discharge unit ensures the air circulation in the panel.

Figure 3.3. Bottom view (outside view)

3.2 Opening of the SPCS / H unit

3.2.1 Door opening

The cabinet door can be opened and closed with a universal key, which is a part from the delivered set and only when the main AC and DC switches are both turned OFF.

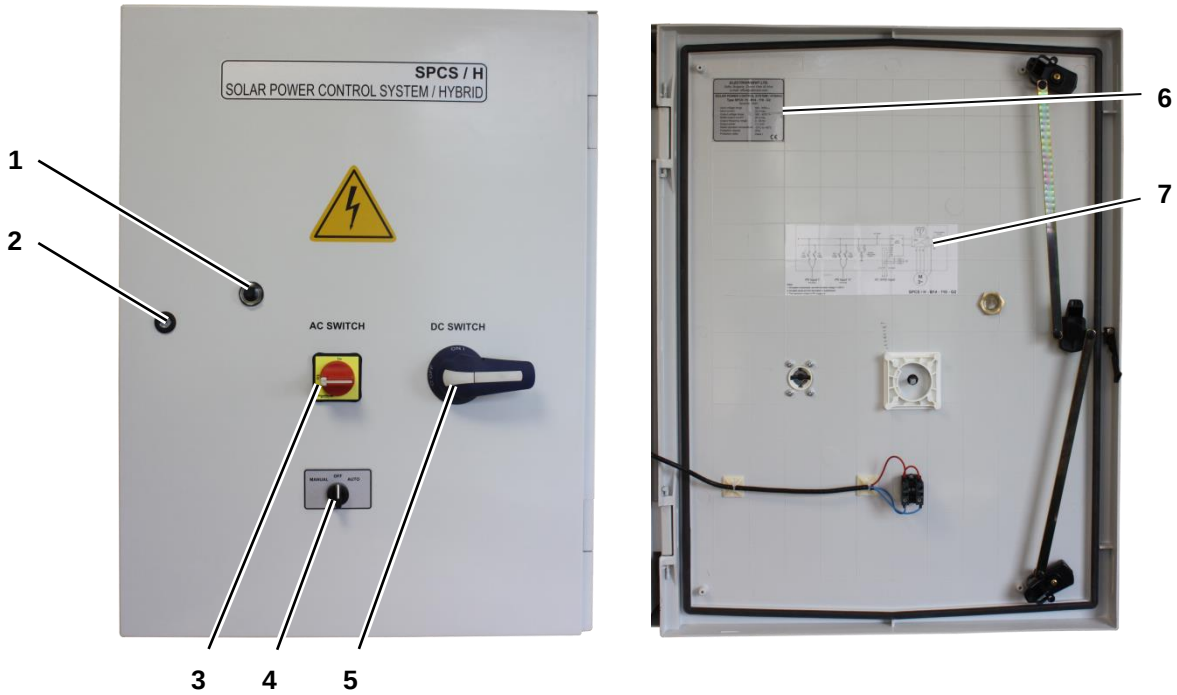


Figure 3.4. The door of SPCS / H unit

Where:

1. *Inverter state LED indication window*
2. *Lock for opening / closing the cabinet door*
3. *AC switch*
4. *Control switch*
5. *DC switch*
6. *Label*
7. *Electrical wiring diagram*

3.3 Block diagram and working principle of the SPCS / H unit

The block scheme of the unit is shown on *Figure 3.5*

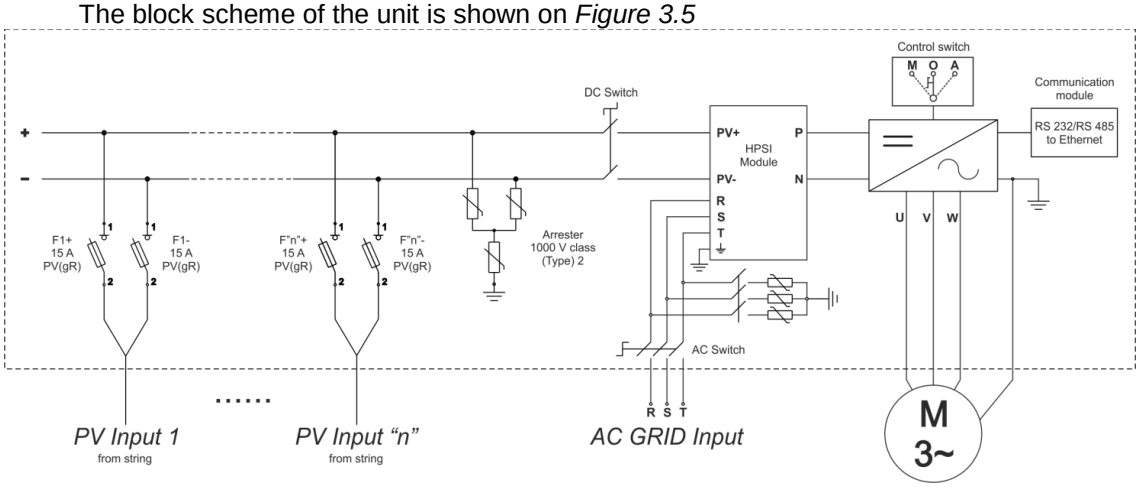


Figure 3.5. Block scheme of SPCS / H

The DC voltage, generated from solar radiation in PV panels, is supplied in the cabinet through PV input terminals (PV+ and PV-). The PV Input Terminals are protected individually with appropriate fuses, corresponding to the string current. Currents from all strings are collected and through DC breaker (Main DC Switch) are supplied to the HPSI module "PV Input".

The AC grid voltage is supplied to the cabinet through the AC Grid Input Terminals. Then through the main AC Switch it is supplied to the HPSI module "AC Input".

The output of the HPSI module forms the inverter's DC-bus voltage on the DC-link capacitor group. There are power connections between the HPSI module output, the DC-link capacitors and the inverter's power input.

There are surge arresters on the PV input side and on the AC grid input side for protection from overvoltage transients, which could be caused either from external (for example lightning), or internal (power stages switching) events.

The inverter converts the DC bus voltage into three-phase alternative voltage suitable to control the AC motor, driving the pump. The inverter controls the input parameters of the system and by enough solar radiation supplies the pump motor with voltage 3x400V_{AC}; 50Hz.

By insufficient solar radiation there are two possible ways of pump control. *First,* if the AC grid and PV array are both connected, then we have so called proportional mode - the inverter consumes the maximum allowable energy from the PV panels and, if it is not enough, it takes the rest of the energy from the AC power grid and supplies the pump motor with its rated power (which is achieved, when the inverter supplies the pump with voltage 3x400V_{AC}; 50Hz). *Second,* if the cabinet's AC Switch is turned "OFF", so the inverter is supplied only from the PV array, when PV power goes down, the inverter automatically reduces the frequency of its output voltage, which leads to reducing of the power fed to the pump motor. The frequency could be reduced to preliminary specified minimal value, which depends on the parameters of the concrete pump installation (this is a system parameter, which must be adjusted on the concrete pump installation; for example it could be 30Hz on one installation and 35Hz on other, etc.). This parameter is dependent on the pump type, the water source, the water level depth, etc.

Briefly, the system tracks the maximum power point of the PV array and accordingly feeds the power to the pump – when it is supplied only from PV array (the AC Switch is turned "OFF"), it changes (reduces) the inverter output frequency, from its rated value 50Hz/60Hz (in the meaning of "U/f=const." motor control) and feeds the pump motor with maximum possible power from the panels at this moment. If the system is working in proportional mode (the AC Switch is turned "ON"), it consumes the maximum possible power from the PV array and if it is insufficient, it takes the rest of the energy from the AC grid, so that the pump works always with its rated power. If there is no PV supply (only AC grid), the system works as grid connected frequency drive.

3.4 Choice of PV fuses

Positive and negative poles (for crystal – CR panels) of single strings are protected individually with fuses, corresponding to maximal current of the PV strings.

- The maximum operating DC voltage of the fuse has to be: 1.2 x maximal voltage of the string.

- The nominal current of the fuse has to be bigger or equal to: 1.6 x I_{SC} by standard test conditions (STC); (I_{SC} – short circuit current of the PV panel).

The main technical parameters of the Fuses are described in *Table 3.1*.

Table 3.1 Choice of fuses

I_{SC} Short circuit current of PV panel [A] STC	Nominal current of the fuse [A]	Size [mm]	Pre-arching Joule integral [A^2s] L/R=2ms	Operating Joule integral [A^2s] L/R=2ms
≤ 2 A	4 A	10x38	3.3	28
≤ 3 A	6 A		5.5	45
≤ 5 A	8 A		8	62
≤ 6 A	10 A		11	88
≤ 8 A	12 A		23	180
≤ 10 A	16 A		35	270

Notes:

- The fuses are preliminary installed by the producer in accordance with customer requirement (for appointed current). The fuses have to be chosen according to *Table 3.1.*
- **In case the customer has not announced the current in advance, the producer supplies the unit with 15A fuses!**

3.5 Choice of place for installation

- SPCS / H unit is suitable for outdoor mounting.
- SPCS / H unit has to be situated possibly closest to the motor, driving the pump.
- SPCS / H unit has to be freely accessible for operation and maintenance.
- It has to be chosen place without direct solar radiation.
- SPCS / H unit has to be mounted this way, to minimize or to prevent collection of water or pollution.

DANGER

Dangerous for life voltage!

Even, the main AC and DC switches are turned OFF, **AC grid input** and **PV inputs and DC side** can be under dangerous for life voltage.

DANGER

The assembling works in SPCS / H unit must be performed by authorized and trained staff only. During all the time it must be sure, that there are no voltages at PV inputs and DC side, and also at AC grid input.

Disassembling of protection covers in the cabinet can be performed by authorized personnel only. During all the time it must be sure, that there are no voltages at PV inputs and DC side, and also at AC grid input.

3.6 Electrical Installation

DANGER

Installation of the unit must be performed by authorized personnel only. During all the time it must be sure that there are no voltages (PV and DC link, and AC grid input).

DANGER

The unit operates with dangerous for life voltages. The strings of photovoltaic modules can be under voltage, when DC switch is turned OFF and the fuses of strings are taken out.

DC-link of the unit stays for some time under voltage, even when the AC and DC switches of the unit are turned OFF.

After turning OFF the AC and DC Switches, wait 10 minutes, before opening the cabinet door or turning it ON again!

ATENTION

Supplying lines have to be mounted in the way, not allowing to be destroyed by rodents.

ATENTION

Electrical lines cannot contact with combustible materials.

3.6.1 Cable inputs/outputs

Figure 3.6. Cabinet cable's inputs and outputs (outside bottom view)

Where:

1. PE (grounding);
2. Inverter Output (3x400V_{AC}; **0**÷50Hz/60Hz/) for power supplying of the water pump induction motor;
3. AC Grid Input (3x400V_{AC}; 50Hz/60Hz/);
4. PV Strings Inputs (PV +);
5. PV strings Inputs (PV -);
6. "Communication Module" I/O connection;
7. "Water Level Control" module sensors connection;

3.6.2 Overview of SPCS / H Main Components Location

Location of the main components of the SPCS / H unit is shown on *Figure 3.7*

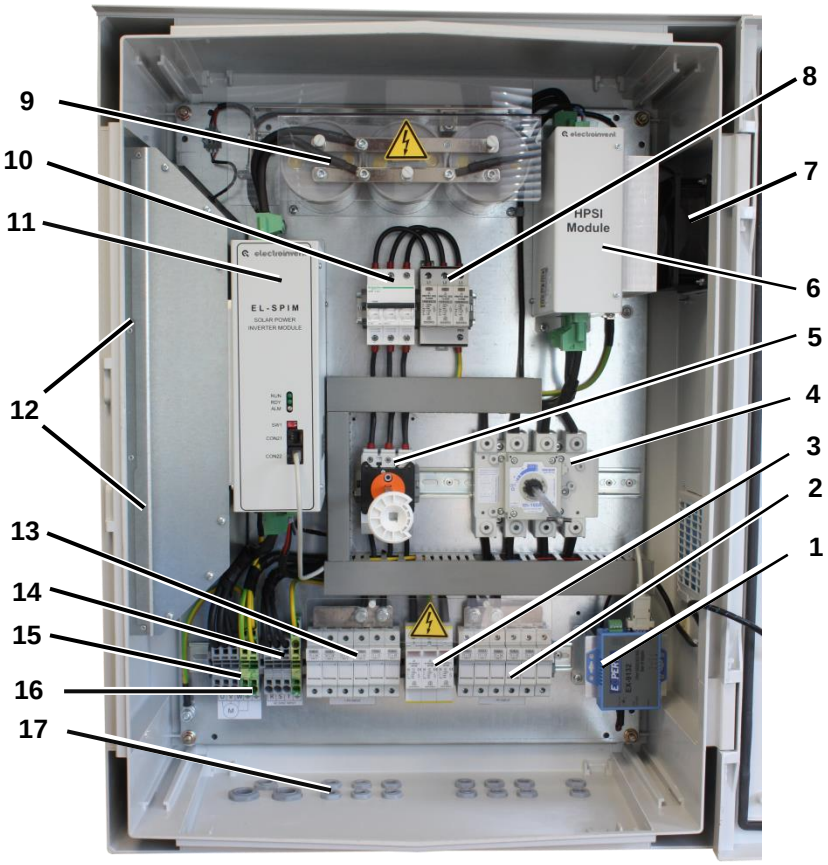


Figure 3.7. Location of the main components of the SPCS / H unit

Where:

1. Communication Module – optional;
2. Fuse holders and Fuses for "**PV-"** inputs;
3. Arrester for overvoltage transients protection (PV Side);
4. Main DC switch;
5. Main AC Switch;
6. HPSI Module;
7. Cooling fan (for HPSI module);
8. Arrester for overvoltage transients protection (AC Grid Side);
9. DC-link capacitor group and protection cover;
10. Arrester circuit breaker (AC Grid Side);
11. Solar Power Inverter Module (EL-SPIM);
12. Air duct protection cover, cooling fan and filter
13. Fuse holders and Fuses for **PV+** inputs;
14. AC Grid Input Terminals (R, S, T, PE) - 3x400V_{AC}; 50Hz(60Hz);
15. Inverter Module Output Terminals U, V, W, PE (3x400V_{AC}; 0÷50Hz/60Hz/) for power supplying of the pump motor;
16. PE terminal for connection with grounding of the PV array construction;
17. SPCS / H Cabinet cable inputs/outputs;

3.6.3 Electrical Connection of SPCS / H unit

The electrical wiring diagram of SPCS / H unit and the cross section of the power cables are shown of *Figure 3.8*.

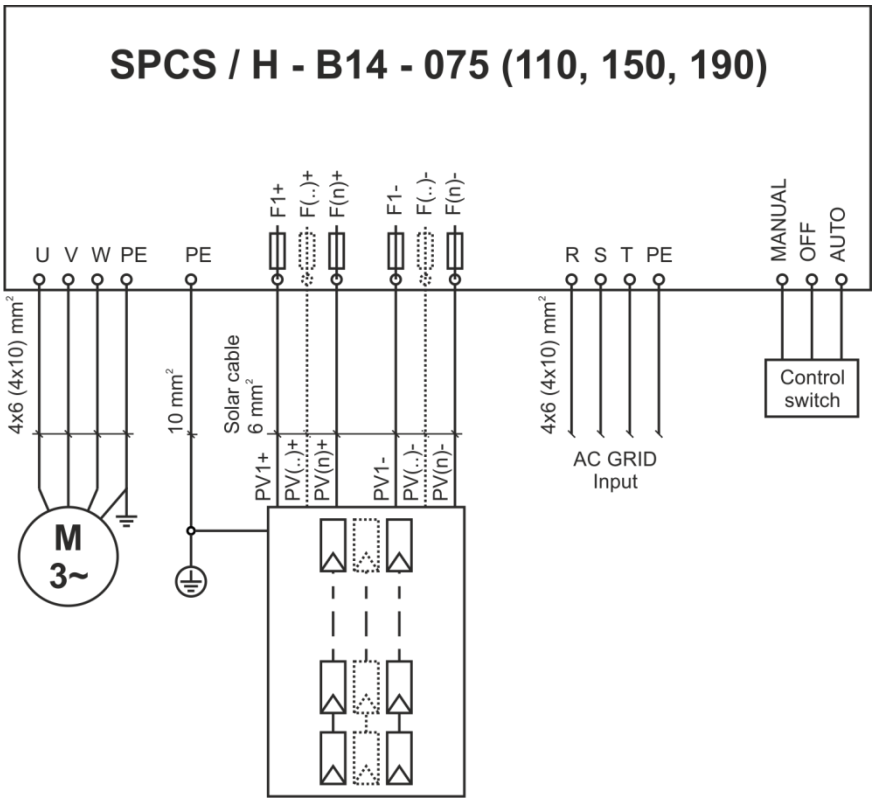


Figure 3.8. Electrical Wiring Diagram of SPCS / H unit

3.6.4 Power Connections of PV Strings, AC Grid and Pump AC Induction Motor

ATTENTION

Observe the correct polarity of PV panels. Wrong polarity connection of PV panels can bring to serious damage in the PV modules.

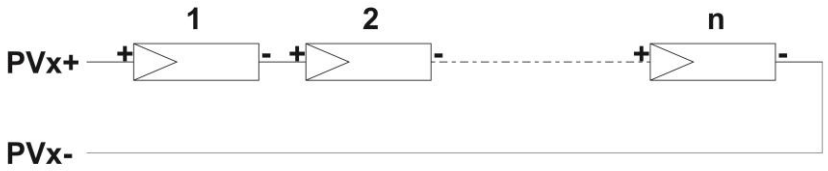


Figure 3.9. Connection of PV panels in string

ATTENTION

Never supply DC input with voltages higher than 800V. Higher voltages can bring to damage of the unit. Improper operation with the unit can bring to loss of warranty and falling away the responsibility about consequent damages.

DANGER

In case of wrong polarity of the strings, never interrupt electrical flow from insulation fuse-holders of the fuses.

DANGER

Insulation holders of the fuses must be opened only in cases, when there is no electrical current (cut-off connection to PV panels or when there is no solar radiation).

Connections of the **PV strings**, **AC grid** and **pump AC induction motor** have to be performed according to the following sequence:

1. **TURN OFF** the cabinet main **DC and AC Switches** and **Control Switch** and open the cabinet door.
2. Open the insulation fuse-holders (see *Figure 3.7. pos. 2* and *pos. 13*)
3. Connect cables of PV strings according to *Table 3.2.*
4. Perform measuring the voltage of the strings and check their polarity.
5. Close the fuse - holders.
6. Connect the AC Grid power line cable to the AC Grid Input Terminals (see *Figure 3.7* and *Table 3.3*).

DANGER

BE SURE THAT THE AC GRID POWER LINE CABLE IS NOT UNDER VOLTAGE!!!

THE AC GRID VOLTAGE MUST BE DISCONNECTED FROM THE MAIN AC GRID DISTRIBUTION CABINET IN THE CONCRETE POWER INSTALLATION!!!

THE CONNECTION IN THE AC GRID DISTRIBUTION CABINET MUST BE ELECTRICALLY SAFEGUARDED!!!

7. Connect the pump motor cable to the inverter module output terminals (see *Figure 3.7* and *Table 3.3*). **Check that the inverter output phases are connected properly and according to the pump motor markings, so that the pump motor will be expected to rotate in the proper direction!**
8. Close the cabinet door and check that the inverter module goes in the proper “Ready” state (see through the LED indication window; **refer to page 43**), by turning ON, consecutively, only the DC switch and after that only the AC switch **(before turning ON the AC switch, check that there is proper AC voltage on the AC Grid Terminals from the AC Grid Distribution Cabinet).**
9. Proceed with turning ON the pump **(from Control Switch, see *Table 3.7* on page 22)**. Check that the direction of the pump motor rotation is correct. **In case of wrong phase connection, so that the pump is rotating in wrong direction, two of the inverter output phases must be exchanged on the inverter output terminals! ALL CABINET SWITCHES MUST BE TURNED OFF!!!**
10. Proceed with inverter minimum output frequency adjustment (refer to the parameter “**Freq.Min Hz**” (see page 26 - inverter software parameters description *Table 5.1*).

DANGER

ALL CABINET INPUT/OUTPUT CONNECTIONS AND ADJUSTMENTS MUST BE PERFORMED BY AUTHORIZED AND QUALIFIED PERSONNEL ONLY!!!

Table 3.2. Connection of strings PV+ and PV-

Terminal	Function	Specification
PV+ Input	F1+; F(..)+; F(n)+ (positive poles) “n” – depends on the cabinet power and the relevant number of strings.	Rotating torque for tightening Nominal / maximal: 2.0 / 2.5 Nm Cross section of connecting cable: 4 - 10 mm^2 Cable lugs: 5 - 10 mm
PV- Input	F1- ;F(..)-; F(n)- (negative poles) “n” – depends on the cabinet power and the relevant number of strings.	Rotating torque for tightening Nominal / maximal: 2.0 / 2.5 Nm Cross section of connecting cable: 4 - 10 mm^2 Cable lugs: 5 - 10 mm

Table 3.3. AC Grid, pump motor and grounding power connections table

Terminal	Function	Specification
AC Grid Input (R, S, T, PE)	Connection of the AC Grid power line	Connection type - spring terminal. Cross section of connecting cable: 4 - 10 mm^2
Inverter Output (U, V, W, PE)	Connection of the inverter output to the pump motor	Connection type - spring terminal. Cross section of connecting cable: 4 - 10 mm^2
PE	Grounding	Connection type - spring terminal. Cross section of connecting cable: 6 - 10mm^2

3.6.5 Connection of the Communication Interface

In order to make the Ethernet connection, the customer must pass and connect the communication module of the SPCS / H unit by a LAN cable.

The connections must be performed according to *Table 3.4* in the following sequence:

Table 3.4 Communication interface connections to SPCS / H unit – option 2 (see Figure 3.11)

Terminal	Function	Specification
Communication Module connector	Communication connection	Connection type: LAN cable Cross section of connecting cable: standard

Both, the 3G and GPRS, modems need a proper SIM card, which must be configured to the customer's country GSM network.

Table 3.5 Communication interface connections to SPCS / H unit – options 3 and 4 (see Figure 3.12)

Terminal	Function	Specification
Communication 3G or GPRS modem	Communication connection	Connection type: SIM card The card must be configured to the customer's country GSM network

3.6.6 Inverter Module Input – Output Interface Description

The Solar Power Inverter Module - SPIM, as a part of SPCS / H unit, has the following built in Input / Output interface, which can be used for configuring the SPCS / H or when the unit is a part from bigger automation system. The Input / Output interface of the inverter module is described in *Table 3.6* below.

Table 3.6 Input / Output interface of the inverter module

Connector Designator	Pin №	Pin Signal Name	Description
CON21	1	N.C.	Not connected
	2	N.C.	Not connected
	3	N.C.	Not connected
	4	A_RS485	Data (-)
	5	B_RS485	Data (+)
	6	N.C.	Not connected
	7	+5V_COMMUNICATION	Isolated safety potential (+5VDC).
	8	GND_COMMUNICATION	Isolated safety potential.
CON22	1	N.C.	Not connected
	2	N.C.	Not connected
	3	TX_RS232	Transmit signal
	4	A_RS485	Data (-)
	5	B_RS485	Data (+)
	6	RX_RS232	Receive signal
	7	+5V_COMMUNICATION	Isolated safety potential.
	8	GND_COMMUNICATION	Isolated safety potential.
CON23	1	+24V_Safe	Isolated safety potential (+24VDC).
	2	GND_Safe	Isolated safety potential.
	3	COM_IN	Common potential for the isolated digital inputs. If the +24V_Safe supply is used for driving the inputs, pins 2 (GND_Safe) and 3 (COM_IN) must be connected to each other.
	4	D_IN1	Multifunctional digital input 1. Active level +24VDC. Default configuration is “Start in Auto Mode” (digital input function 3).
	5	D_IN2	Multifunctional digital input 2. Active level +24VDC. Default configuration is “Start in Manual Mode” (digital input function 2).
	6	D_IN3	Multifunctional digital input 3. Active level +24VDC. Non-configured by default.
	7	D_IN4	Multifunctional digital input 4. Active level +24VDC. Non-configured by default.
	8	D_IN5	Multifunctional digital input 5. Active level +24VDC. In the current software version this input is fixed as counter input (timer input).
CON24	1	D_OUT1	Open collector type (output transistor permissible collector-emitter voltage +30VDC and collector current 20mA). Non-configured by default.
	2	D_OUT2	Open collector type (output transistor permissible collector-emitter voltage +30VDC and collector current 20mA). Non-configured by default.
	3	COM_OUT	Common potential for the isolated digital outputs.
	4	GND_Safe	Isolated safety potential.

Connector Designator	Pin №	Pin Signal Name		Description	
	5	+10V_REF		Analog reference voltage (+10VDC / 20mA).	
	6	ANA_IN+		Differential analog input hardware configurations: • Differential line 4-20mA / Input Resistance 250Ω. • Voltage input: 0-10 VDC. (±5V with offset adjustment).	
	7	ANA_IN-			
	8	ANA_GND		Analog ground.	
CON25	1	+12V_Safe		Isolated safety potential (+12VDC). Communication module power supply.	
	2	GND_Safe		Isolated safety potential.	
CON26	1	NO	Relay output 1	Normally opened contact in relation to the common node 1.	Contact parameters: 8A / 250VAC.
	2	COM		Common node 1.	
	3	NC		Normally closed contact in relation to the common node 1.	
	4	NO	Relay output 2	Normally opened contact in relation to the common node 2.	Contact parameters: 8A / 250VAC.
	5	COM		Common node 2.	
	6	NC		Normally closed contact in relation to the common node 2.	

Note:
The connectors from the table above are shown on the pictures below (see *Figure 3.10*).

Figure 3.10. – SPIM I/O connectors position

3.6.7 Connection of SPCS / H Communication Modules

Option 2 - RS232/485 to Ethernet

The connection for the Ethernet communication is realized by an additional LAN cable provided by the customer, which must be put and connected as shown on *Figure 3.11*.

Figure 3.11. Connection of Communication unit

Please refer to the "RS232/RS485 to Ethernet User Manual – Rev.00" provided separately in the set, if this option is available in the cabinet.

Note: *All communication adjustments must be done by qualified personnel*

Option 3 - RS232 to 3G

Option 4 - RS232 to GPRS

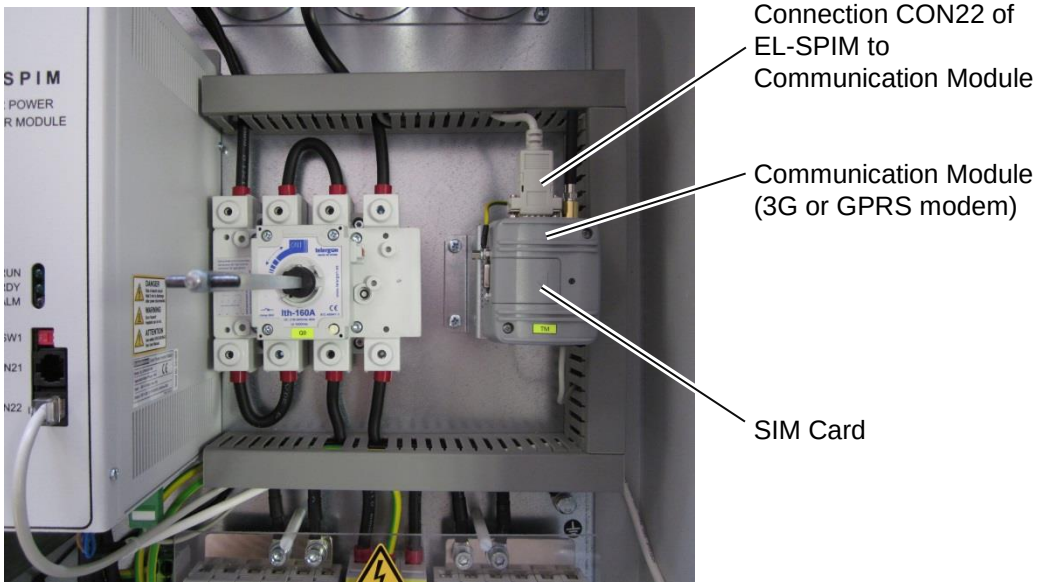


Figure 3.12. Connection of communication unit

Please refer to the "Solar Power Control System_MTX-3G-Java Modem Manual-Rev.00." provided separately in the set, if this option is available in the cabinet.

3.6.8 Water Level Control - Option 5

This option provides the possibility for management of the drive running, according to the water level in wells, tanks (buckets) or both. This is implemented with, so called “WLC” module and one or two sets of water level sensors (electrodes).
Water level sensor bucket (well) positioning and possible PUMP ON and PUMP OFF levels in case of water well are shown on *Figure 3.13*. The distance between the electrodes is determined by the sensitivity of the sensor inputs – the resistance between the common electrode and the low or high electrodes must be ≤ 30kΩ.
For this option could be used a set/sets of the following water level sensors (level electrodes for conductive liquids) from “Lovato Electric” - type 11SN13, or similar. This option provides also an additional LED indication for the drive state.

For detailed description of the WLC module, please refer to “Water Level Control Module User Manual”.

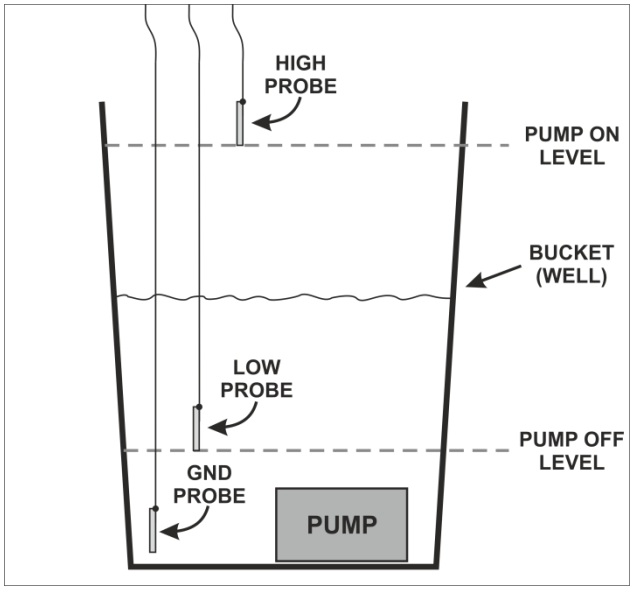


Figure 3.13. Water level sensor bucket (well) positioning.

3.6.9 Control Switch Functionality Description

The control switch positions are described in *Table 3.7* below.

Table 3.7 Control switch positions

Pos.	Control switch positions	Functionality Description
1	MANUAL	Applies active level to inverter module digital input 2 (D_IN2 / CON23), which default function is configured to “Start in Manual Mode”. If the switch position “MANUAL” is permanently active: - the inverter does not start automatically, when input voltage appears. Instead, the inverter control system waits until the switch is deactivated (pos. “OFF”), then activation of the function (pos. “MANUAL”) starts the inverter. - In case that the drive is stopped by any electronic self-protection, subsequent disappearance of the fault condition does not restore normal drive operation. Instead, the inverter control system waits until the switch is deactivated (pos. “OFF”), then activation of the function (pos. “MANUAL”) starts the inverter.
2	OFF	Inverter is in “Ready” mode (not running), waiting for start signal (control switch positions “MANUAL” or “AUTO”).
3	AUTO	Applies active level to inverter module digital input 1 (D_IN1 / CON23), which default function is configured to “Start in Auto Mode”. If the switch position “AUTO” is permanently active: - the inverter starts automatically, when the input voltage appears - in case, that the drive is stopped by any electronic self-protection, subsequent disappearance of the fault condition restores normal drive operation.

NOTES:

- Please see page 30 from this manual.
- The positions from the table above are shown on the picture below (*Figure 3.14*).

Figure 3.14. Control switch

4 Replacement of Defected Components

DANGER

The work, described below, has to be done by qualified personnel only, trained to work with photovoltaic installations.

DANGER

The SPCS / H cabinet operates with dangerous for life voltages. The strings of photovoltaic modules can be under voltage, when DC switch is turned OFF and the fuses of the strings are taken out.

DC-link of the unit stays for some time under voltage, even when the AC and DC switches of the unit are turned OFF.

After turning OFF the AC and DC Switches, wait 10 minutes, before opening the cabinet door or turning it ON again!

ATTENTION

Use only fuses intended for photovoltaic applications. Otherwise system protection will be not secured and guaranteed.

4.1 Replacement of fuse

ATTENTION

Keep instructions in the manual for exploitation, delivered with SPCS / H unit.

1. **Switch OFF** the main **DC and AC switches**, and the **Control Switch**!
2. Wait 10 minutes and then open the cabinet door!
3. Disconnect and safeguard the string cables!
4. Check the fuses one by one to find out which of them are interrupted.
5. Pull out the insulation holder of the fuse.

Figure 4.1. Replacement of the PV fuse

6. Replace the fuse with new one, correctly chosen according the rules (*Figure 4.1*).

ATTENTION

Wrongly chosen fuse can bring to damages in the unit and PV strings.

7. Close the insulation holder of the fuse.
8. Connect the string cables again.
9. Close and lock the cabinet door.
10. Turn ON the main DC and AC Switches.

4.2 Replacement of discharger for overvoltage transients protection (arresters)

If discharger (A) is activated, the green indicator changes its color to red.

1. Switch OFF the main DC and AC switches, and the Control Switch
2. Wait 10 minutes and then open the cabinet door!
3. Disconnect and safe the string cables!
4. Pull out the defected discharger; pulling the insulation holder and placing the new one (see *Figure 4.2*).

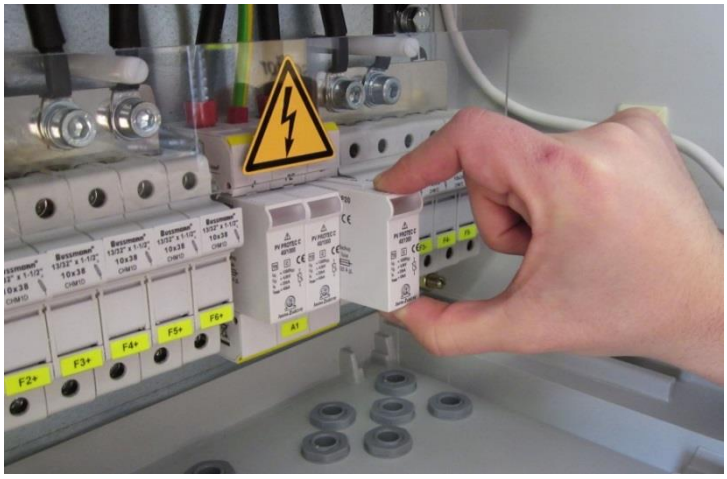


Figure 4.2. Discharger for overvoltage protection

5. Connect the string cables again.
6. Close and lock the cabinet door.
7. Turn ON the main DC and AC Switches.

4.3 Replacement of fan and finger guard filters

The filters on the fan and the finger guard protect the unit from entering of dust and pollution. Filters must be periodically checked and replaced, because if they become dirty, it will bring to worsen cooling of the system and its stop to operate.

Take out the filters of protective finger guard and the fan in the sequence according to shown pictures:

Figure 4.3. Cooling fan filter replacement

Use a filter with the following technical parameters:
Fine filter mats – made of chopped – fiber mat with a progressive structure.
Temperature – resistance to +100°C, self-extinguishing category F1 to DIN 53 438.
Dust – laden air site: Open structure.
Clean – air side: Closed structure.
Reliable filtering of virtually all types of dust from a particle size of 10µm.
Recommended type: Art.No 3238.055 – producer *RITTAL* Company.
After replacement of filters carefully assemble the components in reverse of disassembling order.
As result of the performed check-up and analysis you have to define the periodicity for replacement of filters, which mostly depends on the dust pollution in the environment, where the unit operates.

4.4 Replacement of a cooling fan

By defected fan the system will operate limited time, as well as the cooling of the inverter module and other components in the system cannot be secured.
The reason for fan burning can be also the filter contamination, which brings to fan overload.
The fan replacement must be performed by qualified specialists or service engineers.
Please contact with the service center of the company producer!

5 Software Functional Description

5.1 Parameters of frequency inverter (Software Rev.36)

Parameters of frequency inverter are grouped in 14 functional menus, described below.

Table 5.1. – Parameters of frequency inverter

5.1.1 Menu 0 (a) – Setting of inverter output frequency

№	Parameter	Explanation	MODBUS address	Range		Factory setting
a.00	Freq.Ref Hz	Frequency Reference [Hz]	0x0000	0 – 70	Hz	50.0
a.01	Freq.Min Hz	Minimal operational Frequency [Hz]	0x0001	0 – 50	Hz	30.0

5.1.2 Menu 1 (b) - Visualization

№	Parameter	Explanation	MODBUS address	Range		Factory setting
b.00	Disp.Par.ID	Choice of variable for visualization: **0** : **DC voltage** across the capacitor battery **1** : **output phase current** of the inverter **2** : **input DC current** of the inverter **3** : **output frequency** of the inverter **4** : **drive condition** **5** : **software version** **6** : **state** of **digital inputs** of the inverter **7** : **state** of **digital outputs** of the inverter **8** : inverter **output line-to-line voltage** **9** : estimated **power factor** of the motor	0x0100	0 – 9	V = A ~ A = Hz - - - V ~ -	0
b.01	Displ.Value	Present value of selected variable	0x0101		-	-

5.1.3 Menu 2 (c) – Motor Parameters

№	Parameter	Explanation	MODBUS address	Range		Factory setting
c.00	Unom V	Nominal line-to-line voltage	0x0200	100 – 420	V~	400
c.01	I_nom A	Nominal phase current	0x0201	0.5 – 255.0	A ~	Depends on SPIM power
c.02	Pole pairs	Number of pole pairs	0x0202	1 – 4	-	2
c.03	Frq Max Hz	Maximal frequency	0x0203	25 – 400	Hz	55
c.04	Frq Base Hz	Base frequency	0x0204	100 – 6000	Hz	50

5.1.4 Menu 3 (d) – Common adjustments

№	Parameter	Explanation	MODBUS address	Range		Factory setting
d.00	MainsVtg V	Nominal grid voltage	0x0300	127 – 440	V~	400
d.01	fInvert.kHz	Inverter switching frequency	0x0301	1 – 5	kHz	2
d.02	Fan-On Levl	Cooling Fan switch-on level	0x0302	0.00 – 1.00	-	0.72
d.03	Prot.Enable	Activation/Deactivation of protection against output phase loss during motor rotation 0 – protection is disabled 1 – protection is enabled	0x0303	0 – 1	-	1
d.04	Stop Mode	Inverter Stop Mode 0 – controlled stop with speed ramp, preset in deceleration time 1 – free (uncontrolled) stop	0x0304	0 – 1	-	0
d.05	Defaults/Save	**1**: Loading of saved backup configuration from flash memory into operational memory **2**: Creation of backup configuration by copying the adjusted parameter values from operational memory into flash memory **3**: Forced copying of adjusted parameter values from operational memory into "automatic" area in flash memory Refer to section **5.3.4** for more details on this topic	0x0305	0 – 3	-	0

5.1.5 Menu 4 (e) - Multifunctional inputs

№	Parameter	Explanation	MODBUS address	Range		Factory setting
e.00	AnaInp1 Fnc	Multifunctional **Analog input 1** In present software version the use of the Analog input is fixed – for connection of solar radiation sensor with analog output	0x0400	0 – 0	-	0
e.01	DigInp1 Fnc	Multifunctional **Digital input 1**	0x0401	0 – 107	-	3
e.02	DigInp2 Fnc	Multifunctional **Digital input 2**	0x0402	0 – 107	-	2
e.03	DigInp3 Fnc	Multifunctional **Digital input 3**	0x0403	0 – 107	-	7
e.04	DigInp4 Fnc	Multifunctional **Digital input 4**	0x0404	0 – 107	-	0
e.05	DigInp5 Fnc	Multifunctional **Digital input 5** In present software version the use of digital input 5 is fixed – for connection of sensor with pulse output (counter) for water volume measurement.	0x0405	0 – 0	-	0

NOTE: Refer to Chapter **5.2.1** for detailed explanation of Multifunctional Inputs configuration and usage.

5.1.6 Menu 5 (f) – Multifunctional outputs

№	Parameter	Explanation	MODBUS address	Range		Factory setting
f.00	IoOut1 Func	Function on digital output 1 (reed-relay)	0x0500	0 – 103	-	0
f.01	IoOut2 Func	Function on digital output 2 (reed-relay)	0x0501	0 – 103	-	0
f.02	IoOut3 Func	Function on digital output 3 (open collector)	0x0502	0 – 103	-	0
f.03	IoOut4 Func	Function on digital output 4 (open collector)	0x0503	0 – 103	-	0

NOTE: Refer to Chapter **5.2.2** for detailed explanation of Multifunctional Outputs configuration and usage

5.1.7 Menu 6 (g) – Configuring of analog input

№	Parameter	Explanation	MODBUS address	Range		Factory setting
g.00	AnaInp Gain	Analog input Gain	0x0600	0.000 – 4.000	-	1.00
g.01	AnaInp Ofst	Analog input Offset	0x0601	-9999 +9999	-	0

5.1.8 Menu 7 (h) – Ramp acceleration and deceleration

№	Parameter	Explanation	MODBUS address	Range		Factory setting
h.00	RampAcc .1s	Positive acceleration from 0 to f_{max}	0x0700	0 – 32760	0.1s	65
h.01	RampDcc .1s	Negative acceleration from f_{max} to 0	0x0701	0 – 32760	0.1s	65
h.02	I-Lim Ramp	Negative acceleration in regime of high current limitation	0x0702	10 – 1000	0.1s	50

5.1.9 Menu 8 (I) – Current limitation

№	Parameter	Explanation	MODBUS address	Range		Factory setting
i.00	IlimLo/Inom	Current limitation – low level	0x0800	20% – 170%	-	135%
i.01	IlimHi/Inom	Current limitation – high level	0x0801	20% – 200%	-	160%
i.02	Ovrld Timer	Timer protection from overload	0x0802	500 – 32750	ms	32000
i.03	Ovrld Scale	Overload Coefficient	0x0803	100% – 150%	-	120%

5.1.10 Menu 9 (j) – Communication

№	Parameter	Explanation	MODBUS address	Range		Factory setting
j.00	Baud / 100	Choice of speed on RS232 serial port: 9600, 19200, 38400 (bit/sec) The value is entered without the two trailing zeroes	0x0900	96 – 384	baud /100	192
j.01	Parity	Parity control: **0** – No parity control **1** – Odd number of "ones" in each symbol **2** – Even number of "ones" in each symbol	0x0901	0 – 2	-	0
j.02	Stop bits	Number of stop-bits	0x0902	1 – 2	-	1
j.03	Node ID	MODBUS node Identifier	0x0903	1 – 247	-	1
j.04	Mbs.timescl	MODBUS communication timeout correction	0x0904	0.100-1.900	-	1.000

5.1.11 Menu 10 (l) – V-Hz curve

№	Parameter	Explanation	MODBUS address	Range		Factory setting
l.00	Ustart/Umax.	Output voltage at Zero Frequency	0x0A00	0.0%–20.0%	-	0.0%
l.01	Uboost/Umax	Output voltage at Boost Frequency	0x0A01	0.0%–25.0%	-	0.0%
l.02	Ubase/Umax	Output voltage at Motor Base Frequency	0x0A02	25.0%-100.0%	-	100.0%
l.03	Fboost/Fmax	Boost Frequency	0x0A03	0.0%–50.0%	-	0.0%

5.1.12 Menu 11 (n) – Solar Control

№	Parameter	Explanation	MODBUS address	Range		Factory setting
n.00	SolarPiRegP	Proportional (**P**) Gain of the **PI**-regulator which controls the inverter output frequency	0x0B00	0.000–1.000	-	0.025
n.01	SolarPiRegI	Integral (**I**) Gain of the **PI**-regulator which controls the inverter output frequency	0x0B01	0.000–0.100	-	0.008
n.02	SolarVtgCrt	Proportion of the Minimal allowable operating voltage to the Open Circuit voltage of the solar panel	0x0B02	0.000–0.900	-	0.800
n.03	Restrt[sec]	Interval (in seconds) for restarting the inverter	0x0B03	10 – 1800	-	240
n.04	LogInt[min]	Interval (in minutes) for logging of inverter operative data in internal non-volatile memory	0x0B04	0 – 60	-	5
n.05	IrradScaler	Irradiance sensor scaling factor	0x0B05	0.050-1.000	-	0.470
n.06	MPPT-To[ms]	MPPT Cycle Time in milliseconds	0x0B06	500-9999	-	2000
n.07	MPPT-Step	MPPT Step	0x0B07	0.000-0.010	-	0.002

5.1.13 Menu 12 (o) – Visualization of the main operating variables

№	Parameter	Explanation	MODBUS address	Range		Factory setting
o.00	Time [min]	Minutes from entering the pump in operating regime	0x0C00	-	-	-
o.01	DC Vtg [V]	DC voltage on the input of the inverter	0x0C01	-	-	-
o.02	DC Crnt [A]	DC current consumed on the input of the inverter	0x0C02	-	-	-
o.03	DC Pwr [W]	DC power on the input of the inverter	0x0C03	-	-	-
o.04	AC Vtg [V]	Line voltage on the output of the inverter	0x0C04	-	-	-
o.05	AC Crnt [A]	AC phase current on the output of the inverter	0x0C05	-	-	-
o.06	AC Pwr [VA]	AC power on the output of the inverter	0x0C06	-	-	-
o.07	OutFreq[Hz]	Output frequency of the inverter	0x0C07	-	-	-
o.08	Irrad[]	Measured solar radiation	0x0C08	-	-	-
o.09	Pump Out []	Volume of pumped water	0x0C09	-	-	-

5.1.14 Menu 13 (p) – Pump operation control

№	Parameter	Explanation	MODBUS address	Range		Factory setting
p.00	Min.PwrFctr	Minimal Power Factor level for “dry run” detection	0x0D00	0.00–0.80	-	0.35
p.01	Tmeout[sec]	Sets the time interval(in seconds) the ‘dry run’ condition must persist before ‘dry run’ protection is activated and the drive is disabled	0x0D01	5–120	-	5
p.02	Restrt[min]	Sets the time interval(in minutes) before automatic drive restart is attempted in case of ‘dry run’ activation	0x0D02	5 – 1440	-	30

5.2 Configuration and Activation of Digital Input / Output Functions

5.2.1 Configuration and activation of digital input functions

A set of digital inputs is provided to control the inverter. Each digital input can be assigned different function according to the characteristics of the technological process and the customer preferences. This is done by assigning any of the available set of digital input functions to some digital input. All input functions will be listed and explained in this chapter further bellow.

Assigning a function to given digital input is done in **Menu 4** – "**Multifunctional inputs**", where each of the digital inputs is presented by separate parameter. We choose the digital input to which we want to attach a function, and then we set the parameter corresponding to this input to the value corresponding to the needed function.

After a function has been configured (assigned) to a digital input, activation of the input activates also the attached function. Activating the input means to feed an active level (voltage) by closing or opening of contact connected to it. The type of active level (if activating is done by closing or opening) also can be chosen individually for each input – this will be described further below in this chapter.

Summary:
In order to activate some digital input function, you need to attach this function to some digital input, and then the input has to be activated by feeding the chosen active level.

Digital Input Functions

Table 5.2. Digital Input Functions

№	Name	Description
0	Not configured	There is no function assigned to this input.
1	Emergency stop	By activating of this function the motor stops. Until this function is active, inverter cannot be started.
2	Start (Manual Mode)	If voltage is present at the inverter input, we activate Function **2** to start the drive. If Function **2** is permanently active (corresponding input switch permanently ON, control switch position "MANUAL"): - the inverter does not start automatically when input voltage appears. Instead, the inverter control system waits until Function **2** is deactivated, then activation of the function starts the inverter. - In case that the drive is stopped by any electronic self-protection, subsequent disappearance of the fault condition does not restore normal drive operation. Instead, the inverter control system waits until Function **2** is deactivated, then the function activation starts the inverter .
3	Start (Auto Mode)	If voltage is present at the inverter input, we activate Function **3** to start the drive. If Function **3** is permanently active (corresponding input switch permanently ON, control switch position "AUTO"): - The inverter starts automatically when input voltage appears. - In case that the drive is disabled by any electronic self-protection, subsequent disappearance of the fault condition restores normal drive operation.
4	Level above upper limit	If this function is activated (by exceeding the upper limit level of the tank): the inverter stops and the pump stays switched-off until activation of function **6** („Level below lower limit")
5	Level bellow lower limit	If this function is activated (by the water level gone bellow lower limit): the inverter drives the motor on condition that **Run Manual**(**2**) or **Run Auto**(**3**) function is active and **Emergency stop** function(**1**) is not active. **Note**: if neither **5**, nor **6** functions are configured, the inverter is controlled by the **Run** and **Emergency Stop** functions only.
6	Level Control	This input function implements drive control via single level sensor. When the water level is below the sensor limit, the inverter drives the motor on condition that **Run Manual**(**2**) or **Run Auto**(**3**) function is active and **Emergency stop** function(**1**) is not active. The drive is disabled if the water level exceeds the limit.

№	Name	Description
7	Grid Present	This function should be assigned to some digital input if the drive is intended to operate in “dual supply” (hybrid) mode, i.e. when both DC input (from PV) and AC input (grid) are connected to the drive. A grid-detection sensor, connected to the same digital input, informs the drive control system about actual presence / absence of AC grid, which is necessary for efficient drive control in hybrid mode.

By configuring input functions with numbers (values) shown in above table, activation of given function is done by closing the contact, connecting the corresponding digital input to the source of operational voltage. Deactivation is done by opening of the same contact. In case it is necessary to implement the reverse logic (activating by contact opening) the values of functions from the table have to be modified by adding an offset of 100.

Example 1: We want to assign input function **2** (**Start Manual Mode**) to digital input **1**, so that this function is activated by closing of a contact.
In Menu 4 “**Multifunctional inputs**” we find the parameter, corresponding to digital input **1**: This is parameter **e.01**.
We give **e.01** the value of **2**. So function **2** is assigned to digital input **1**.
Function **2** is activated by closing the contact, connected to input **1**.

Example 2: We change the conditions in Example 1, so that the function **2** is activated by opening of a contact and is deactivated by closing the contact.
In accordance with the principle, depicted above, we set parameter **e.01** to the value **2**+**100**, i.e. **102**.
So function **2** is assigned to digital input **1**, but now it is activated by opening of a contact connected to input **1** and it is deactivated by closing the same contact.

5.2.2 Configuration and activation of digital output functions

A set of digital outputs provide inverter state feedback. Each digital output can be assigned some of the available set of digital output functions. All output functions will be listed and explained in this chapter further bellow.

Assigning a function to given digital output is done in **Menu 5** – “**Multifunctional outputs**”, where each of the digital outputs is presented by separate parameter. We choose the digital output to which we want to attach a function, and then we set the parameter corresponding to this output to the value corresponding to the needed function.

After a function has been configured (assigned) to a digital output, activation of the assigned function activates also the related output. Activating of relay output means its transition to active condition (closed or open contact).

The type of the active condition (closed or open contact) is configured individually for each input – this will be described further below.

Summary:
In order to activate some digital output, we attach some digital output function to it.
Then, activation of the configured function activates the output to which the function is attached – the output goes to the chosen active state.

Table 5.3 – Digital Output Functions

№	Name	Description
0	Not configured	There is no function assigned to this output.
1	Ready	This digital output function is activated after drive power-up initialization is complete on condition that there is no electronic self-protection activated by some fault condition.
2	Start / Stop	This digital output function is activated, when the inverter is started – AC voltage is present on its output terminals. The digital function is deactivated when there is no voltage on the output terminals (the inverter is switched-off). So, the **Start/Stop** output may become active only when some **Start** input function is activated and there is no fault condition present.
3	Pump Running	This digital output function is activated when the inverter is switched on and supplies to the motor voltage with frequency, bigger than the configured minimal operating output frequency of the pump. Active condition of this function is indication that the motor secures the pump high enough speed to be able to pump the water.

By configuring of digital output functions with numbers (values) given in above table, activation of given function leads to closing of contact on digital output, to which this function is assigned. Deactivation of output function leads to opening of the same contact. In case it is necessary to realize reverse logic (opening of contact by activation), the values of functions in the table should be modified by adding an offset of **100**.

Example 3: We want to assign output function **3** („Pump operates") to digital output **0**, so that by activating of the function the relay contact on output 0 is closed.
In Menu 5 "**Multifunctional outputs**" we find the parameter, corresponding to digital output **1**: this is parameter **F.00**. On **F.00** we assign value **3**. So the output function **3** is assigned to digital output **1**.
By activating of output function **3** the relay on digital output 1 closes its contacts.

Example 4: We change the conditions of Example 3, so that by activating of output function **3**, digital output **1** to open its contacts and to close it by deactivating of function **3**. In accordance with principal shown above, on parameter **F.00** we assign value **3**+**100**, i.e. **103**. So the output function **3** is assigned to digital output **1**, but by activating of the function, the contact is opening, and by deactivating it is closing.

5.3 Description of Inverter Module Menus and Parameters

5.3.1 Menu 0 (a) – "Setting of inverter output frequency"

Parameter **a.00** (**Frequency Reference**) sets the maximal output frequency, which the inverter can achieve in case of high irradiance, ensuring enough energy flow from the solar panels. In lower irradiance conditions the output frequency set point is provided by the 'Solar' **PI**-Regulator which sustains the highest possible output frequency for given irradiance conditions.

Parameter **a.01** (**Minimal operational Frequency**) sets a lower limit for the inverter/pump operation. In poor irradiance conditions the highest achievable output frequency/motor velocity, might be too low for the pump to ensure any water flow. So, the motor/pump would rotate at low speed to no avail.

Therefore, normal pump operation assumes that the pump motor rotation speed does not fall below some minimal value at which water flow stops. If the incoming energy flow from the PV panels is not sufficient to sustain this minimal output frequency, then the inverter control system disables the inverter output and the pump stops for certain time interval before a new attempt to accelerate the drive above the minimal frequency is tried. This retry interval is configured (in seconds) through the **n.03** – **Restrt**[sec] parameter in Menu 11. Automatic restart is launched only in case that the **Automatic Start** input is active.

5.3.2 Menu 1 (b) – "Visualization"

The menu consists of two parameters.
The first (**b.00**) is index, by which can be chosen some of the liable to visualization variables.
The second (**b.01**) is "read-only" parameter (only for reading) in which the chosen for visualization variable appears.
The values, which can accept **b.00**, as well as the corresponding list of variables for visualization, are shown in paragraph **5.1.2**.
For visualization of given variable by operation with software **ConfigMaster**, should be kept the following sequence:

- It is assigned the desired value of index **b.00** (with this it is choosing the variable for visualization)
- With right button of the mouse should "click" upon first or second column of **Menu 1** and from the open context menu should be chosen "Download Menu **1**", thus refreshing the content of parameter **b.01**, where the chosen variable in correct format appears.

Note:
The visualization cell (Parameter **b.01**), can be chosen for permanent observation by "click" with right button upon the last column on **Menu 1**/ Parameter 01.
By this the colors of the frame are changing and the software starts periodical refreshment of its content. The exit from the regime of permanent observation can be done by secondary "click" upon the same cell on the table.
By analogic way any other "read-only" parameter can be chosen for permanent observation. It is not allowed simultaneous setting in regime for observation of two or more parameters.

5.3.3 Menu 2 (c) – "Motor Parameters"

For the motor control mode „Constant **U/f** proportion", used in this type of inverters, some of parameters in **Menu 2** are important for control of the pump motor, others are used only to calculate the values, which are visualized or are written into the log file, preserved in the internal energy-independent memory of the inverter.
The important parameters for the control of AC induction motor are:

- **c.00** – Nominal line voltage
- **c.01** – Nominal phase current
- **c.03** – Maximal frequency
- **c.04** – Base frequency

Nominal voltage and current, as well as the base frequency can be taken from the motor label or from producer documentation of the pump.
The value of **c.03** (Maximal frequency) can be specified equal or a little higher than the base frequency. This parameter specifies the upper limit, to which can be increased the frequency reference in **Menu 0**.
Parameter **c.05** – Power factor is used to calculate the active output power of the inverter and can be taken also from the label of the motor or pumps documentation.
Parameter **c.02** (Number of pole pairs) is not substantial for this mode of motor control.

5.3.4 Menu 3 (d) – "Common adjustments"

d.00 – "**MainsVtg**"
By supply from electrical grid, this is the nominal effective value of the line voltage.
By supply from solar panels, the value of this parameter is specified equal to their nominal voltage (depending from the type and number of in series connected panels), multiplied by coefficient, equal to **0.707** (reciprocal value of squire root of 2)

d.01 – "**fInvert.kHz**"
This parameter specifies the inverter switching (carrier) frequency. The range for setting is 2 – 5(kHz). The main considerations for the choice of switching frequency are:

- higher output frequency of inverter requires also higher switching frequency.
- but higher switching frequency causes higher commutation losses in the inverter power stage.
- lower switching frequency produces higher acoustic noise in the motor.

As the drives for water pumps operate with low output frequency (up to 60 Hz), it is preferred the carrying frequency not to exceed 5 kHz. Typical adjustment would be between 2 and 5 kHz. The acoustic noise from the motor is of no importance for this type of drives, and relatively low switching frequency helps against overheating of power transistor unit.

d.02 – "**Fan-On Levl**"
This parameter sets the temperature of power unit, at which the inverter cooling fan is switched-on. Lower value of this parameter secure lower temperature for fans switch-on.
By value zero, the fan will be permanently switched-on, irrespective of the temperature of the power unit.

d.03 – "**Prot.Enable**"
The inverter is supplied with electronic protection against interruption of output phase between inverter and pump motor. The protection is activated during rotation and break down of the output phase, which prevents the motor from possible damage.
In case of inclination towards false activation of this protection, it can be disabled, by setting **d.03** to the value of **0**. Value of **1** enables the protective function.

d.04 – "**Stop mode**"
Parameter **d.04** defines the drive behavior on removing the **Start** signal (setting the **Start** input to inactive state) while the pump motor is rotating.
If **d.04** is set to the value of **0**, then the inverter brings the motor to standstill by decreasing the output frequency in accordance with the Deceleration Ramp, configured by parameter **h.01** (controlled stop).
If **d.04** is set to the value of **1**, then the motor coasts freely to standstill (uncontrolled stop).

d.05 – "**Defaults/Save**"
Parameter **d.05** serves mainly to store entire configurations in permanent (flash) memory of the inverter, as well as to restore written configurations. When the inverter is power supplied, the configuration parameters, specifying the behavior of the drive, are kept in an energy dependent operational memory (RAM).

By switch-off of the power all parameters from the running configuration are automatically saved in energy independent (non-volatile) FLASH memory. By switching-on of the power, all parameters from energy independent memory (FLASH) are transferred into operational memory. So the inverter configuration is restored from the last switch-off. This is so-called **"automatic configuration"**, which is preserved and restored automatically, without external command.

By change of some configuration parameters it is possible to reach to unwanted behavior of the drive compared with its condition before start of the changes. In case a lot of changes are made, the restoration "by memory" of the last working configuration can be impossible. To secure taking out from such unfavorable situation, it is foreseen a possibility for saving the **"reserve configuration".** This configuration is saved in separate zone in flash-memory that is not affected by automatic writing at power-down.

It is recommended after change of configuration parameters, by reaching well working configuration, this configuration to be written as a "reserve" one. This can be done as on **d.05** is assigned value of **2**: **d.05** = 2 (after writing of configuration, the value on **d.05** automatically returns in **0**). So written reserve configuration stays unchanged until not being overwritten in already described manner.

Copying of reserve configuration from flash-memory into operative memory becomes as on **d.05** is assigned value of **1**: **d.05** = 1. The running configuration can also be written in the flash-memory not only automatically (at power-down), but also forcefully – as on **d.05** is assigned value **3**: **d.05** = 3.

Note: Each of these operations can be activated only in inactive condition of inverter – when the **Start** input is inactive.

5.3.5 Menu 4 (e) – "Multifunctional inputs"

Each of parameters **e.00** – **e.05** in this menu corresponds to one physical input of the inverter.

Input **e.00** is analog and in the present version of the device it is not multifunctional, but it is intended to connect an analog signal from irradiance sensor.
The other inputs are digital.

Input **e.05** in the present version of the unit is not multifunctional too, it is intended to connect the sensor with pulse output to measure the water volume.

Digital inputs **e.01** – **e.04** are multifunctional and each of them can be assigned some of the available digital input functions, as described in **5.2.1** – **„Configuration and activation of digital input functions"**

5.3.6 Menu 5 (f) – "Multifunctional outputs"

Each parameter (**f.00**, **f.01**, **f.02**, **f.03**) of this menu corresponds to one of inverter's four digital outputs.

f.00 and **f.01** correspond to the two relay outputs.
f.02 and **f.03** correspond to the two 'open collector' outputs.

All digital outputs are multifunctional and each of them can be assigned some of available digital output functions, as described in **5.2.2** – **„Configuration and activation of digital output functions"**

5.3.7 Menu 6 (g) – "Configuring of analog input"

Coefficient of amplification, as well as the offset of analog input of the inverter can be adjusted by parameters **g**.**00** and **g**.**01.**

5.3.8 Menu 7 (h) – "Acceleration and deceleration ramp"

By parameters **h.00** and **h.01** can be specified positive acceleration (by starting run) and negative acceleration (by stop) of the motor.
Acceleration is assigned as time for change of output frequency of the inverter
- from 0 to specified reference frequency for positive acceleration
- from specified reference frequency to 0 for negative acceleration (by stop).

The time is assigned as units 1/10 of a second.
For example adjustment 100 of the time for positive acceleration (**h.00**) corresponds to 100 x 1/10 = 10 (Sec). This is a small acceleration, corresponding to smooth run-up of the pump and such adjustment for positive acceleration is typical for this type of drives.

Parameter **h.02** assigns negative acceleration, by which the frequency reference is decreased in high current limitation regime (refer to **5.3.9** for more details). Because of specifics of the motor load (pump characteristic), and due to the assigned big times for acceleration, entering the regime of high current limitation is practically excluded and that's why the manufacturer default adjustment of this parameter is not necessary to be corrected.

5.3.9 Menu 8 (I) – "Current limitation"

i.00 specifies a 'low limitation' threshold for the motor phase current. In case of exceeding this limit, the motor acceleration is temporarily stopped (the output frequency reference is "frozen" at its present value) until the phase current drops below the low limitation threshold, then the motor acceleration is resumed.

i.01 specifies a 'high limitation' threshold for the motor phase current. In case of exceeding this limit, the output frequency reference is being gradually reduced until the phase current drops below the high limitation threshold, then the motor acceleration is resumed. The slope of output frequency reference reduction is set by **h.02** parameter from "Acceleration and deceleration ramp" menu.

Both **i.00** and **i.01** are non-dimensional values specified against the adjusted nominal motor current. If sufficiently long acceleration time is set by **h.00** parameter, the pump acceleration goes smoothly, so in practice there is rather small probability of entering any of the current limitation regimes.

i.02 is a parameter which sets a timer for drive overload protection.
The overloading protection is activated in case of continuous operation at motor phase current greater than the adjusted nominal current of the motor.

The time is assigned in milliseconds. For example, the adjustment of **i.02** = 5000 means, that the overload protection will be activated after operation longer than **5** seconds at current bigger than the nominal value.

5.3.10 Menu 9 (j) – "Communication"

The **RS485** serial port (**CON21** and **CON22** of the inverter module), operates at fixed communication parameters as follows:

- Speed **9600** bit/sec
- **No** Parity Control
- Number of Stop Bits: **1**

j.00, **j.01** and **j.02** parameters set the communication parameters for the **RS232** serial port (**CON22**)

- **j.00** sets the communication speed. Available values are 9600, 19200 and 38400 bit/sec. The preferred speed value is entered in **j.00** as listed above just the trailing two zeroes are omitted. As an example, the 19200 bit/sec speed is set by **J.00** = 192.
- **j.01** sets the parity control: **0** (No Parity), **1** (Odd Parity), **2** (Even Parity).
- **j.02** sets the Stop Bits number: 1 or 2 Default **CON22** settings are: **19200**, **N**, **8**, **1**. (number of data bits in character is always 8).
- **j.03** sets the device identifier number in a MODBUS network(MODBUS Node ID). In accordance with MODBUS protocol, possible values range from 1 to 247. Default value is 1.
- **j.04** is a scalar used for modifying the MODBUS inter-frame timeouts from their standard values. This may be needed for interoperation with devices which don't strictly abide by MODBUS standard.

Default setting for **j.04** is **1.00**, which ensures standard MODBUS inter-frame timeout.

5.3.11 Menu 10 (l) – "V-Hz curve"

The inverter implements the well-known 'Constant Volt per Hertz' control method. The parameters of this menu set the ratio between the amplitude and frequency values of inverter's output voltage.

l.00 and **l.01** configure voltage boost at zero frequency and at the 'boost frequency' respectively (the 'boost frequency' is set by **l.03** parameter). The voltage boost increases motor torque at very low rotation speed at the price of somewhat bigger motor power losses in the low-speed range. For pump drive systems the load at very low rotation speed is inconsiderable, so boosting of output voltage is normally redundant, so **l.00** and **l.01** parameters may keep their default zero values.

l.02 sets the ratio between the voltage at the base (nominal) voltage frequency and the nominal motor Line Voltage, configured through Menu 2 ("Motor Parameters"). Ordinary setting for **l.02** e 1.00 – the voltage amplitude at the nominal frequency is equal to the configured motor line voltage.

l.03 sets the boost frequency value for the U/f curve. According to the considerations given above, Voltage Boost is hardly needed for pump drives, so normally **l.03** may preserve its default zero value.

5.3.12 Menu 11 (n) – "Solar Control"

n.00 and **n.01** parameters set respectively the **P**-component gain and **I**-component gain of the "Solar" Proportionally-Integral Controller (**PI** – Controller) which produces the drive output frequency set-point depending on the measured value of the DC-voltage coming from the PV panels.
"Solar" PI-controller prevents the drive from drawing too much power from the PV-panel in case of insufficient solar radiation. So, it reduces the output frequency set point if the measured PV voltage tends to fall below some critical threshold. This 'Critical Voltage' threshold is defined as proportion of the PV voltage under load towards the PV voltage in idle state ('Open Circuit' PV voltage, **OC**).

n.02 configures the value of the Critical Voltage, depicted above. Normally the value of n.02 coefficient is about 0.80, which means that when the inverter is in operation, its control system tries to ensure maximal possible output frequency without letting the DC voltage drop below 80% of the PV panels Open Circuit(**OC**) voltage value.

n.03 – **Restrt**[sec] sets the time interval(in seconds) between two consecutive attempts to accelerate the pump motor above the configured minimal operational frequency. Refer to the description of Parameter **a.01** (**Minimal operational Frequency**) for more details.

n.04 sets an interval(in minutes) at which certain basic internal parameters of the drive are stored to a log file in the inverter internal non-volatile memory. This log may also keep values of solar irradiance sensor, connected to the inverter external analog input. A dedicated external inverter digital input (pulse counter) is also available where an external water-flow measuring device may be connected and its output stored to the inverter log.

n.05 sets the value for scaling of the analog signal from an external irradiance sensor.

n.06 and **n.07** parameters configure **MPPT**(Maximum Power Point Tracking) operation. MPPT performs continuous automatic correction of the Critical Voltage value (configured via **n.02**) in order to achieve maximal possible frequency on the inverter output. The Critical Voltage value set by **n.02**, is internally summed with a correction value which is periodically re-calculated using the well-known 'Perturb & Observe' algorithm. The intervals for calculation of the correction are set in milliseconds, through **n.06** ('MPPT-Timeout'). The perturbation step is set by **n.07** ('MPPT Step').

5.3.13 Menu 12 (o) – "Visualization of the main operating variables"

The parameter group in Menu **12** is **read-only**. Its purpose is visualization of the instant values of all internal and external variables, which (in averaged form) are stored to the log file as explained in the previous paragraph. Usage of the visualization parameters is described in the Note at the end of paragraph **5.3.2** – Menu "Visualization"

5.3.14 Menu 13 (p) – "Control of pump operation"

As continuous operation of the pump system without fluid is considered an emergency, protection against it is implemented in the drive control system. Menu **13** provides parameters for customizing this protection.
There are two decisions to be made regarding the timing of the 'dry run' protection:

a) How long the 'dry run' condition must exist before turning the drive off.
This timeout value is set in seconds via **p**.**01** (**Timeout** [sec]) parameter.
It shouldn't be too short because transient 'dry run' conditions normally occur during initial drive acceleration. The timeout must not be too long either as prolonged dry rotation may be harmful for the pump. By default the timeout is set to 5 seconds.

b) How long the drive should stay inactive in case it has been turned off due to 'dry run' condition. This interval is set in minutes via **p**.**02** (**Restrt** [min]) parameter. The maximal value of **p**.**02** is 1440 minutes (24 hours). By default the restart interval is set to 30 minutes. Besides, a 'Minimal Power Factor' threshold is set which is used for 'dry run' condition detection. Normally you don't need to change the default value of **0.35** set for this **p**.**0** (**Min**.**PwrFctr**) parameter.

But in some rare cases it might need modification, especially if the pump regime allows continuous operation at speed or load substantially smaller than the nominal ones. In such cases faulty activation of the 'dry run' protection may occur. To avoid it, you may need to slightly decrease the **p**.**0** setting.

To help figure out the meaning of this ''Minimal Power Factor' threshold, here is a brief description of the principle on which the 'dry run' protection implementation is based:

Induction motors are notorious for their poor power factor in case of idle running or when driving small loads. The power factor grows up when the motor load increases and reaches values of about 0.80 or even 0.90 and more at nominal load and nominal speed(depending on motor specifications).

So, knowing the power factor value, the ‘dry run’ condition with respective power factor of the order of **0.20** is easily distinguished from the ‘full load’ condition with power factor around **0.80** or more.

But if the drive is operated at speed/load much smaller than the rated ones, the power factor at this smaller load may occasionally drop below the default value of **0.35**, so some decrease of **p**.**0** parameter value will prevent unwanted activation of the ‘dry run’ protection.

In these unlikely cases, setting the proper value of the power factor threshold is facilitated by the Power Factor monitoring capability of the drive system – refer to the description of Menu 1(**Display**) in paragraph 3.2.
Power factor value is monitored by selecting the value of **9** for the Display Index parameter **b.0.**

5.4 MODBUS Communication

5.4.1 Supported functions of MODBUS protocol

The system supports MODBUS – functions with the following functional codes:

Table 5.4 – Functional codes

03 (0x03)	Read Holding Registers
04 (0x04)	Read Input Registers
05 (0x05)	Write Single Coil
06 (0x06)	Write Single Register
16 (0x10)	Write Multiple Registers

5.4.2 Addressing of parameters and variables of the drive by MODBUS protocol

Each of described inverter configuration parameters may be read / modified by standard functions of MODBUS protocol.

5.4.3 Principle of addressing

Two-byte address for access to any configured parameter is formed this way:

- Most significant byte is the number of the menu to which the parameter belongs;
- Least significant byte is the index of the parameter within the menu;

5.4.4 Format of parameters and variables of the drive accessible through MODBUS

Presentation of parameter values inside the MODBUS Protocol Data Units is depicted below. To add clarity, some examples are included (*please, refer to the screenshot on the next page*).

Both Integer and Real configuration parameters transmitted through MODBUS frames are coded as 16-bit integer values.
Representation of any parameter sent over the serial line depends on the adopted position of the Decimal Point (**DP**) for the parameter.
A parameter value is transformed to Integer through multiplying it by a factor, equal to the **N**-th power of 10, where **N** is the **DP** position.

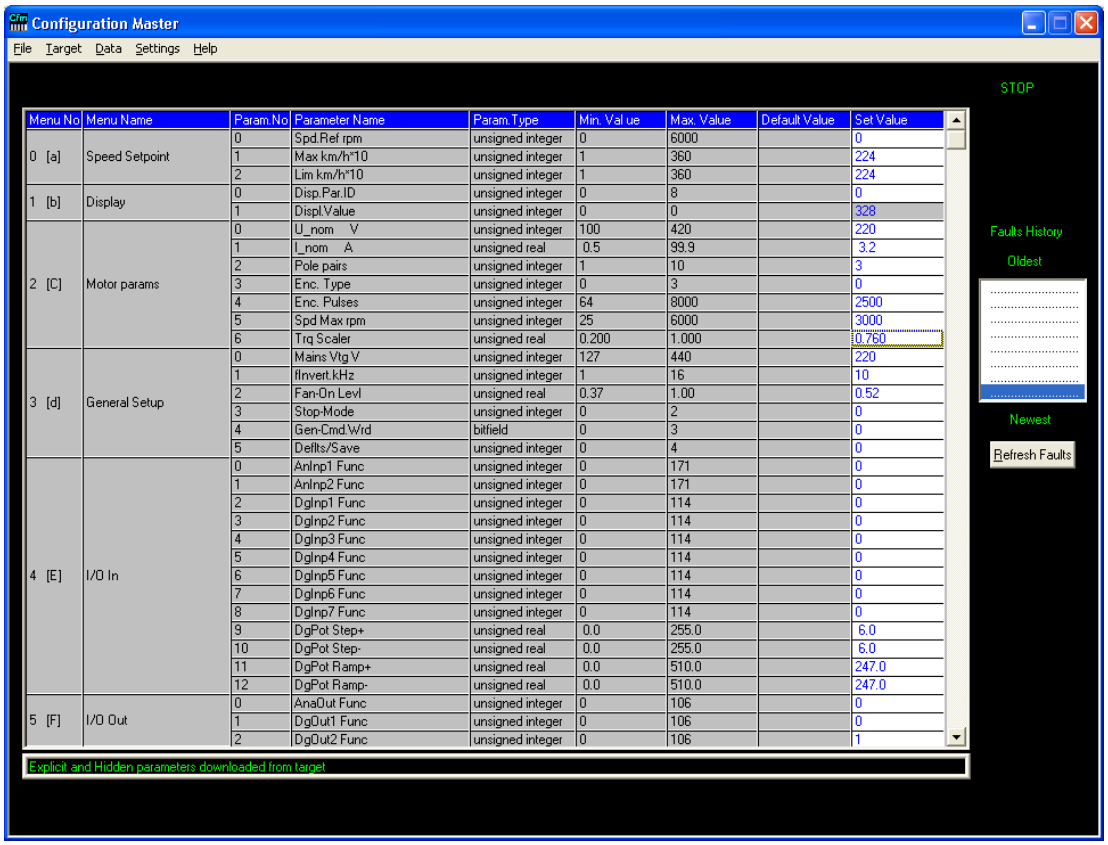
For an Integer parameter DP position is zero, so the transformation factor in this case equals 1 and the value is sent exactly as it appears in the “Set Value” field on the screen.

For a Real parameter the transformation factor, being a power of 10, is big enough to shift the decimal separator to the zero position, converting the Real value into Integer one.

Knowing the DP position for any parameter of interest, the receiving side restores the actual parameter value through dividing the integer number coded in the MODBUS frame by the same transformation factor.

The screenshot below shows part of a Drive Unit configuration downloaded through the “ConfigMaster” tool.

Conversion of Real parameter value to Integer one is illustrated with the example of Parameter 6 in Menu 2 (*Figure 5.1*). There are three digits to the right of the decimal separator there, so the DP position is equal to 3. The transformation factor should be 10^3 = 1000. Hence the value of 0.760 is transformed into 1000 x 0.760 = 760 before being inserted into the MODBUS message frame. On reception the real value is restored through dividing of 760 by 1000.



Menu No	Menu Name	Param.No	Parameter Name	Param.Type	Min. Value	Max. Value	Default Value	Set Value
0 [a]	Speed Setpoint	0	Spd.Ref rpm	unsigned integer	0	6000		0
		1	Max km/h*10	unsigned integer	1	360		224
		2	Lim km/h*10	unsigned integer	1	360		224
1 [b]	Display	0	Disp.Par.ID	unsigned integer	0	8		0
		1	Displ.Value	unsigned integer	0	0		328
2 [C]	Motor params	0	U_nom V	unsigned integer	100	420		220
		1	I_nom A	unsigned real	0.5	99.9		3.2
		2	Pole pairs	unsigned integer	1	10		3
		3	Enc. Type	unsigned integer	0	3		0
		4	Enc. Pulses	unsigned integer	64	8000		2500
		5	Spd Max rpm	unsigned integer	25	6000		3000
		6	Trq Scaler	unsigned real	0.200	1.000		0.760
3 [d]	General Setup	0	Mains Vtg V	unsigned integer	127	440		220
		1	fInvert.kHz	unsigned integer	1	16		10
		2	Fan-On Levl	unsigned real	0.37	1.00		0.52
		3	Stop-Mode	unsigned integer	0	2		0
		4	Gen-Cmd.Wrd	bitfield	0	3		0
		5	Deflts/Save	unsigned integer	0	4		0
4 [E]	I/O In	0	AnInp1 Func	unsigned integer	0	171		0
		1	AnInp2 Func	unsigned integer	0	171		0
		2	DgInp1 Func	unsigned integer	0	114		0
		3	DgInp2 Func	unsigned integer	0	114		0
		4	DgInp3 Func	unsigned integer	0	114		0
		5	DgInp4 Func	unsigned integer	0	114		0
		6	DgInp5 Func	unsigned integer	0	114		0
		7	DgInp6 Func	unsigned integer	0	114		0
		8	DgInp7 Func	unsigned integer	0	114		0
		9	DgPot Step+	unsigned real	0.0	255.0		6.0
		10	DgPot Step-	unsigned real	0.0	255.0		6.0
		11	DgPot Ramp+	unsigned real	0.0	510.0		247.0
		12	DgPot Ramp-	unsigned real	0.0	510.0		247.0
5 [F]	I/O Out	0	AnaOut Func	unsigned integer	0	106		0
		1	DgOut1 Func	unsigned integer	0	106		0
		2	DgOut2 Func	unsigned integer	0	106		1

Figure 5.1. "ConfigMaster" User Interface (Parameter 6, Menu 2)

The following examples illustrate reading / modification message sequences for various parameter formats.

Read Holding Registers (MODBUS Function Code **0x03**)

Menu **2**, Parameter **4**
Reading of **Integer** parameter value **2500** (hex **09C4**)

Table 5.5 - Examples

Request			Response		
01 03 02 04 00 01 C4 73			**01 03 02 09 C4 BF 87**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**04**		RegVal_Hi	**09**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**C4**	
RegCnt_Lo	**01**		CRC_Lo	**BF**	CRC
CRC_Lo	**C4**	CRC	CRC_Hi	**87**	
CRC_Hi	**73**				

Menu 2, Parameter 1
Reading of **Real** parameter value **3.2**, presented as **3.2** x **10** = **32** (hex **0020**)

Request			Response		
01 03 02 01 00 01 D4 72			**01 03 02 00 20 B9 9C**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**01**		RegVal_Hi	**00**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**20**	
RegCnt_Lo	**01**		CRC_Lo	**B9**	CRC
CRC_Lo	**D4**	CRC	CRC_Hi	**9C**	
CRC_Hi	**72**				

Menu 2, Parameter 6
Reading of **Real** parameter value **0.760**, presented as **0.760** x **1000** = **760** (hex **02F8**)

Request			Response		
01 03 02 06 00 01 65 B3			**01 03 02 02 F8 B8 A6**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**02**	Starting Address	ByteCount	**02**	Byte Count
Param	**06**		RegVal_Hi	**02**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**F8**	
RegCnt_Lo	**01**		CRC_Lo	**B8**	CRC
CRC_Lo	**65**	CRC	CRC_Hi	**A6**	
CRC_Hi	**B3**				

Menu 3, Parameter 2
Reading of **Real** parameter value **0.52**, presented as **0.52** x **100** = **52** (hex **0034**)

Request			Response		
01 03 03 02 00 01 25 8E			**01 03 02 00 34 B9 93**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**03**	Function Code	FuncCode	**03**	Function Code
Menu	**03**	Starting Address	ByteCount	**02**	Byte Count
Param	**02**		RegVal_Hi	**00**	Register Value
RegCnt_Hi	**00**	Quantity of Registers	RegVal_Lo	**34**	
RegCnt_Lo	**01**		CRC_Lo	**B9**	CRC
CRC_Lo	**25**	CRC	CRC_Hi	**93**	
CRC_Hi	**8E**				

Write Single Register (MODBUS Function Code **0x06**)

Menu 2, Parameter 4
Writing **Integer** parameter value **2500** (hex **09C4**)

Request			Response		
01 06 02 04 09 C4 CE 70			**01 06 02 04 09 C4 CE 70**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**06**	Function Code	FuncCode	**06**	Function Code
Menu	**02**	Register Address	Menu	**02**	Register Address
Param	**04**		Param	**04**	
RegCnt_Hi	**09**	Register Value	RegVal_Hi	**09**	Register Value
RegCnt_Lo	**C4**		RegVal_Lo	**C4**	
CRC_Lo	**CE**	CRC	CRC_Lo	**CE**	CRC
CRC_Hi	**70**		CRC_Hi	**70**	

Menu **2**, Parameter **1**
Writing **Real** parameter value **3.2**, presented as **3.2** x **10** = **32** (hex **0020**)

Request			Response		
01 06 02 01 00 20 D8 6A			**01 06 02 01 00 20 D8 6A**		
NodeID	**01**	Slave Address	NodeID	**01**	Slave Address
FuncCode	**06**	Function Code	FuncCode	**06**	Function Code
Menu	**02**	Register Address	Menu	**02**	Register Address
Param	**01**		Param	**01**	
RegCnt_Hi	**00**	Register Value	RegVal_Hi	**00**	Register Value
RegCnt_Lo	**20**		RegVal_Lo	**20**	
CRC_Lo	**D8**	CRC	CRC_Lo	**D8**	CRC
CRC_Hi	**6A**		CRC_Hi	**6A**	

5.5 Electronic Protections and LED-indications of the Inverter Operating State

Inverter state indication is implemented by three Light Emitting Diodes (LEDs) – see *Table 5.6*.

Table 5.6. LED indication description

№	*LED Designator*	*LED Color*	*Indicated Drive State*
1	**RDY** (Ready)	**Green**	Normal drive state. It is constantly lit unless some fault condition is detected.
2	**RUN** (Running)	**Green**	Active (running) drive state. A.C. voltage is applied to the motor.
3	**ALM** (Alarm)	**Red**	Blinking indicates presence of fault condition which has activated some electronic self-protection. Please see the description of the "Drive Electronic Protections" *Table 5.8*.

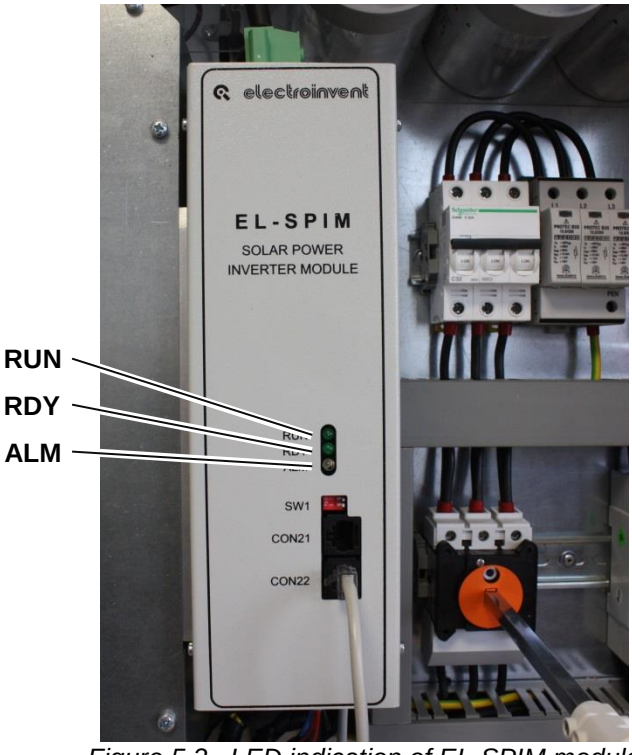


Figure 5.2. LED indication of EL-SPIM module

Drive (inverter) states indicated by the blinking patterns of "**RDY"** and **"RUN"** LEDs – *Table 5.7*.

***NOTE:* In the text below the control switch in position "ON" means that, it is either in "MANUAL" or in "AUTO" position (please see table 3.7 and fig. 3.14).**

Table 5.7. Drive states

№	Indicating LEDs	Indicated Drive State
1	**RDY**	When power is initially applied across the inverter input terminals, it takes some seconds for the high-voltage capacitors to charge, and then the device enters the normal operating condition. The capacitors charging state is indicated by '**RDY**' LED flashing. When charging is complete the '**RDY**' LED stays permanently lit on.
2	**RDY & RUN**	If '**RDY**' LED is lit on, the '**RUN**' LED remains extinct until start command *(control switch in position "ON")* is applied. Then the '**RUN**' LED is lit too, indicating active *(running)* drive state. However, there are cases when '**RUN**' LED is not immediately lit, instead it starts blinking for certain amount of time before being continuously lit on: **1.** There is a minimum time interval between two consecutive starts of the drive. If the control switch is turned from position "ON" to position "OFF" and then immediately switched "ON" again, the '**RUN**' LED starts blinking until this time interval expires. **2.** In **"Auto"** control mode, if the drive is disabled due to insufficient power input from the solar panels, then an automatic start is attempted on expiration of a preset restart time interval. Until this automatic start the '**RUN**' LED keeps on blinking. *In the both cases, described above the '**RUN**' LED blinking indicates, that start command (control switch in position "ON") is applied and pending, but not yet active.*
3	**RDY & RUN**	If power is applied to the drive in ***'Manual Mode'*** (please refer to pages 30-32 – "Digital Input Functions") switch turned ON, then after completion of capacitors charging (indicated by '**RDY**' flashing as described above), the '**RDY**' and '**RUN**' LEDs start blinking alternatively. This flashing pattern indicates that you need to cycle the 'Manual Start' switch in order to enable the inverter, as Manual Start Mode does not allow ***automatic start*** of the drive.
4	**RDY & RUN**	The alternative '**RDY**' and '**RUN**' LEDs flashing described above appears also in case that the 'Emergency' input (please refer to pages 30-32 – "Digital Input Functions") is activated at any time. Flashing stops when the 'Emergency' input is deactivated.
5	**RDY & RUN**	When drive unit operation is controlled by the High and Low Tank Level inputs (please refer to pages 30-32 – "Digital Input Functions"), activation of the "Water Tank High Level" input turns the drive off. This state is indicated by alternative flashing of the '**RDY**' and '**ALM**' LEDs. The state persists until "Water Tank Low Level" input gets active.

ATTENTION

A set of built-in self-protections preserves both, the inverter and the controlled motor from various harmful conditions. Activation of any protection disables the inverter output and stops the drive. In automatic control mode, drive restart is automatically attempted after expiration of the preset restart time interval. The alarm is cleared and the drive is enabled only, if the fault condition has already gone.

When any fault protection is active, the '**RUN**' and '**RDY**' LEDs are turned off and the '**ALM**' LED starts blinking. The '**ALM'** LED blinking pattern consists of series of frequent blinks, separated by longer pauses. The number of consecutive blinks in each series indicates the active fault protection. Drive electronic protections indication table is shown below:

Table 5.8 – Drive Electronic Protections

Number of blinks	***Indicated Alarm State***
1 blink	**Over-Voltage**
2 blinks	**Under-Voltage**
3 blinks	**Short Circuit**
4 blinks	**Over-Current**
5 blinks	**Over-Heating**
6 blinks	**Over-Load**
7 blinks	**Encoder Fault (**not applicable for Solar pump drive systems**)**
8 blinks	**Output Phase Interruption**
9 blinks	**Earth Fault**
10 blinks	**Pump Dry Run**

ATTENTION

In case that the fault condition causing the fault indication has disappeared, this blinking pattern repeats until the restart time expiration. The next automatic start stops the alarm indication and the 'RDY' LED goes on again.

Fault Protection #10 (Pump Dry Run) is indicated a bit differently, than the others. As 'Dry Run' is not really a drive system fault, but an external condition demanding the drive to be stopped, unlike the other faults, the Ready (RDY) LED is not extinguished, while Pump Dry Run alarm is indicated.

Drive State LED Indications – Summary *(Table 5.9):*

Table 5.9. Drive state LED indications

RDY	***RUN***	***ALM***	***Drive State***	***Comment***
Flashing	Extinct	Extinct	Capacitors **Charging**	Lasts approx. 15 seconds
Lit	Extinct	Extinct	**Ready**, 'Start' Not Activated	Control switch in position "OFF".
Lit	Flashing	Extinct	**Ready**, 'Start' Pending	Control switch in position "ON". See *Table 3.7*.
Lit	Lit	Extinct	Ready, Activated - **Running**	Control switch in position "ON".
Lit	Extinct	Flashing	Pump **Dry Run** (Drive disabled)	**10** wink series separated by pauses
Extinct	Extinct	Flashing	**Fault** (Drive Disabled)	From **1** to **9** wink series separated by pauses.
Flashing	Flashing	Extinct	**Drive Off:** "Emergency" active or Inverter powered-up with "Manual Start" active	**RDY** / **RUN** alternatively flashing. To end this state: Remove 'Emergency' input or Cycle the 'Manual Start' input
Flashing	Extinct	Flashing	'**Water Tank High Level**' on	**RDY** / **ALM** alternatively flashing until 'Water Tank Low Level' goes active

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